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An Economic Evaluation of Alberta Farmland Values

by

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Abstract

This study is concerned with the many forces which have an economic influence on farmland values. Participants in the farmland market may not be aware of all factors which influence farmland values. An element of confusion may exist in the farmland market due to uncertainty concerning the effects that future benefits of owning farmland may have on the current market values for farmland. Landowners, potential farmland buyers and farm mortgage lenders share in this uncertainty and thus have a need for greater knowledge of farmland values and their determinants.

The primary objective of the study is to determine those factors which exert an influence on changes in Alberta farmland values which have occurred over time. A further objective is to observe the functioning of farmland markets, particularly with respect to the interrelated nature and the relative magnitude of economic factors. As well, future implications concerning market prices for farmland are evaluated. Economic models are developed to explain Alberta farmland values at the provincial and census division levels. Ordinary least-squares regressions provide estimates of economic relationships which might influence Alberta farmland values. The models are evaluated in both linear and logarithmic forms. The major focus of the empirical research is to determine the factors which could explain variations in farmland values over time. Analysis of pooled cross-sectional and time-series data of census division farmland values are also undertaken in order to include the influence of quantity of farmland transferred.

Statistical complications associated with time-series data limit the number of explanatory variables which may be included in an economic model of the farmland market. Accordingly, no individual model is able to represent all the economic relationships which might function in determining Alberta farmland values. A number of economic models are employed to determine whether hypothesized forces have an influence on farmland values. From the statistical results of these economic models, a number of economic influences on farmland values can be inferred.

The results for variables representing expected productive returns and expected capital gains, suggest these factors are major influences on provincial farmland values. From the estimates for these variables, it appears that emphasis is placed on more recent levels of returns and capital gains rather than those of many past periods. Expected

increases of productive returns and of capital gains (based on previous levels of real capital gains) appear to be related to increasing farmland values. However, the estimated elasticity coefficients for previous farmland values and farm enlargement suggest these factors have the largest relative impact on real farmland values. The results of the regression analyses suggest that farmland purchasers may tend to include information on previous levels of farmland values together with other explanators in decisions relating to farmland values. The results also indicate that the process of farm enlargement over time influences farmland values. This result most likely occurs through the combined influence of technological progress and economies of size. Changes in Alberta farmland values may also be influenced by other forms of technological advance, economic development and concessional credit. These factors all appear to have direct influences on farmland values.

The statistical results are not consistent with the hypothesis that there is a negative relationship between the quantity of farmland transferred and farmland values. As well, a variable measuring the ratio of the index of farm product prices relative to an index of farm mortgage credit costs, appears to have a significant inverse relationship with Alberta farmland values.

The empirical results also provide insights that might aid future studies of farmland values. Improved analyses of farmland values might be achieved through data which are less highly aggregated or data which are transformed to reduce the level of intercorrelation among explanatory variables. As well, more refined analyses of the pooled cross-sectional and time-series data could be achieved through the use of superior regression techniques. Future studies may also pursue questions which have evolved from this study. The nature of farm enlargement could be evaluated to determine whether farm enlargement takes place to achieve economies of scale or to achieve wealth. As well, the influence of concessional credit could be further evaluated to determine the relative impact of the availability of funds and of reduced interest rates (one component of concessional credit) on farmland values.

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I. Introduction

Increasing farmland values are the consequence of numerous forces, particularly those of economic, social, political and legal characters. The objective of this study is to identify those forces having an observed effect on Alberta farmland values. Furthermore, an attempt will be made to determine the importance of the identified factors through estimating the effect of each force on farmland values.

A. Problem Specification

Figure 1.1 illustrates provincial farmland values for Alberta. These have risen continuously from 1940 to 1980. Nominal farmland values have increased 119% from 1940 to 1950, 43% from 1950 to 1960, 90% from 1960 to 1970 and 274% from 1970 to 1980. During this time period, appreciating land values may have contributed to numerous economic consequences in the agriculture sector. Increased values for farmland might aid producers in achieving economies of scale. This result is due to the fact that increased equity bases have allowed producers to acquire additional land and other productive inputs as well as to adopt improved technology. Increasing land values might also prompt less efficient producers to retire from uneconomic units. More recently, high land values may have created barriers to new entrants into the farm sector. Future consequences of changing land values may be substantial losses in equity if the above-noted trend in farmland values were to be reversed.

These economic consequences may be attributed to long term trends in farmland values. However, market participants may not be aware of all factors, particularly in the nonagricultural sector, that have an influence on farmland values. Landowners, potential farmland buyers and farm mortgage lenders may, therefore, have a need for greater knowledge concerning the trends experienced in farmland values.

Quantification of exact relationships between various explanatory variables and farmland values may not be attainable. Although relationships most likely exist, these may change to reflect dynamic economic and social conditions. Perhaps as a result of this, some observers have expressed concerns that farmland might be overpriced relative to its earning abilities. Uncertainty may apply with respect to the relative magnitudes of the many economic, social and political forces which may have an influence on farmland

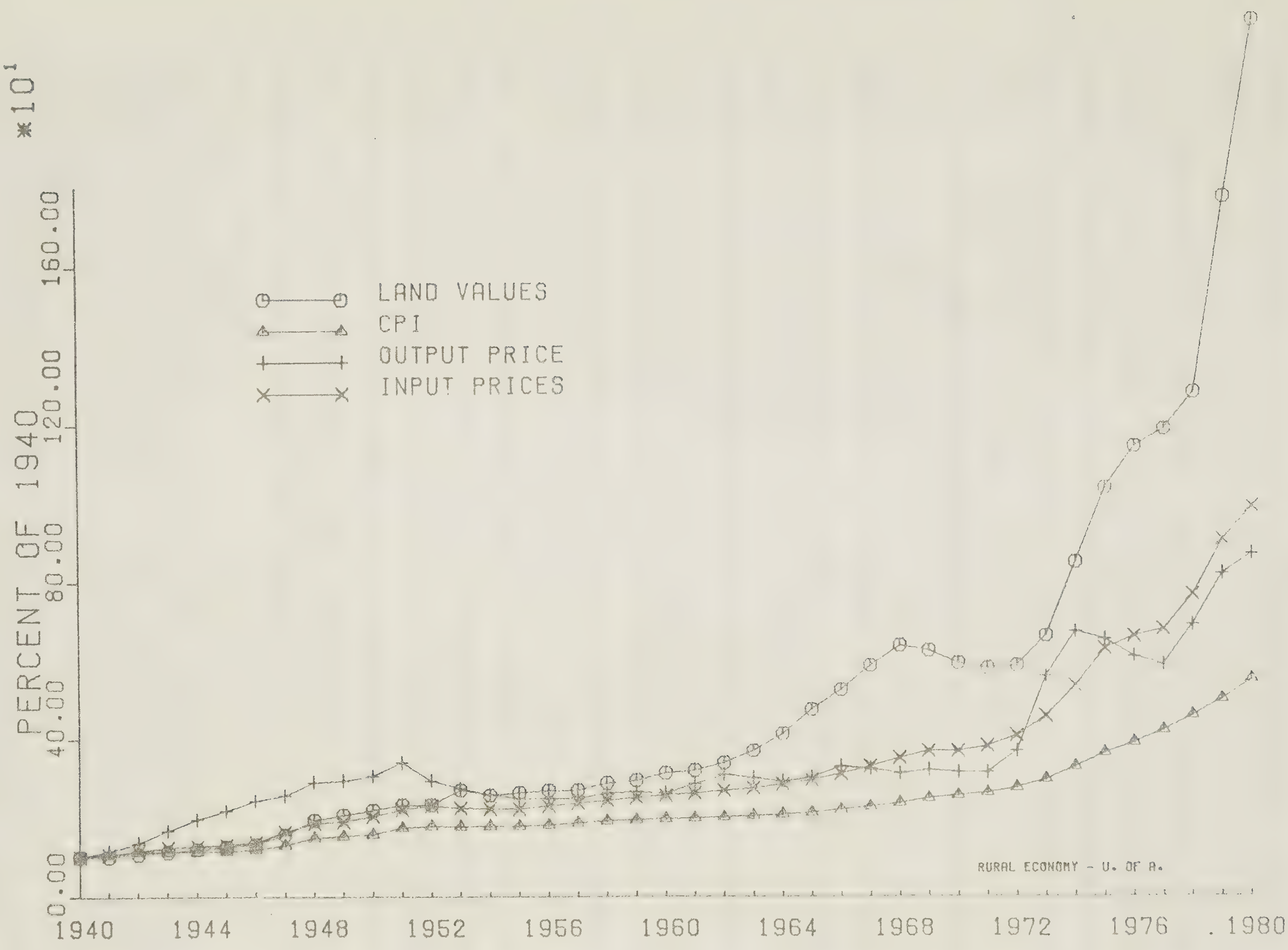

Figure I.1 Trends in Alberta Farmland Values, General Price Levels, Farm Product Prices and Farm Input Prices 1940–1980

values. The presence of uncertainty suggests a problematic situation as described by Northrop, "when the facts necessary to resolve one's uncertainties are not known" (1969, p. 17).

The content of this study will be research focused on questions of fact which originate in the desire for greater knowledge of farmland values. The specific approach will be to pursue a solvable problem, for which the solution will be obtained from observable facts. Accordingly, relevant facts concerning the farmland market are discussed in order to reveal the problem.

Farmland is subject to market and social valuations due to the legal benefits that are attached to farmland ownership. In the case of farmland, property rights are clearly defined, therefore the perceived value of property rights becomes the basis of exchange.[1] A farmland market establishes value for farmland through the interaction of supply and demand forces. These market forces represent perceived values of property rights by sellers and buyers. Perceptions of market value are expected to include both economic value and social value components.[2] Farmland markets are expected to be relatively efficient in achieving allocation of the land resource for all sectors of society. Market value is established through transactions and is expected to reflect present and future net benefits to the landowner. However, future economic and social values will likely evolve in a dynamic environment and future benefits to landowners may be somewhat unknown. As well, uncertainty may be associated with relationships between market values and perceptions of future benefits. Furthermore, the long term perspective which applies to farmland includes many economic, social and political forces. Therefore, there is considerable uncertainty concerning the future benefits of owning farmland. This study attempts to observe from the factual situation the many factors which have an influence on farmland values.

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[1] Property rights are established by legislation to provide legal benefits to land owners. These include the right to use a property, the right to sell it, the right to lease it, the right to enter it and the right to give the property or any of its rights away. The rights attached to ownership of a property are, however, generally limited by the government powers of taxation, police, expropriation and escheat. As well, there are many specific restrictions on the use and enjoyment of land which may arise with respect to issues such as mineral rights and water rights.

[2] Land tends to be used for the purposes of achieving the highest return for the landowner. Economic value thus describes the value of land largely in terms of monetary return. However land provides many benefits and social value perceptions may also contribute to market value. Benefits may be derived from non-economic returns which would include welfare and social considerations.

Potential farmland buyers and sellers are expected to form expectations of the causal forces in the market and of relationships between such forces and land values. Economic relationships which are observed to influence farmland values will reflect the expectations of participants in farmland markets. Accordingly, hypothesized relationships of the forces of expected productive returns, expected capital gains, economic development, technological progress, farm enlargement, government programs, previous farmland values and quantities of farmland transferred can be developed. These hypothesized relationships can be empirically tested to reveal factors which could have an influence on farmland values.

B. Objectives of the Study

The predominant objective of this study is to determine those factors which exert an influence on Alberta farmland values. Consequently, the study attempts to identify variables which affect provincial and census division farmland values over time. Hypothesized relationships will be developed through deductive reasoning, economic theory and the evidence from previous studies of farmland values. These relationships will be tested to ascertain statistical significance and reliability. Further study objectives, therefore, are to quantify relevant variables and develop and test appropriate statistical models using least-squares regression techniques. Time-series data of provincial farmland values and pooled time-series and cross-sectional data for census division farmland values will be used as dependent variables.

Another objective of this study is to gain insight into the functioning of the Alberta farmland market. The intent is to observe the relative magnitudes of explanatory variables and their interrelated activity in the price determining process. A model including many of the important influences on farmland values could provide a basis for decision making and policy formulation with respect to farmland and the economic forces which influence farmland values. A major incentive of this study comes from concerns for the future economic consequences of changing farmland values. Therefore, a further objective of this research is to discuss future implications for farmland values with respect to factors found to have an influence on them.

C. Organization of the Study

This study consists of seven chapters as well as appendixes and bibliography. Chapter One discusses the problem and describes the objectives of the study. Chapter Two examines economic theory as it relates to the market for farmland. Included in this examination are theoretical concepts relating to supply and demand, production, economic rent and the capitalization process as well as institutional considerations. Chapter Three provides a review of previous literature dealing with farmland values. Both analytical and empirical contributions to the study of farmland values are discussed. Chapter Four develops hypotheses to explain changes in farmland values.

Chapter Five is an empirical methods chapter in which econometric models of the farmland market are developed, statistical techniques to estimate variable coefficients are described and statistical complications are acknowledged. Chapter Six presents the empirical results and provides statistical and economic interpretations of these results. Chapter Seven develops economic conclusions and economic implications from these results.

II. Theoretical Concepts Relating to the Market for Farmland

A. Introduction

Both analytical and empirical bodies of knowledge are drawn upon to achieve an understanding of market values for farmland. Economic theory evolves from the analysis of different economic processes. Land values are determined in markets that are influenced by many forces. Economic theory attempts to disaggregate these forces as a means of describing market behavior. This disaggregation is typically accomplished by using assumptions in achieving conclusions which indicate how economic agents respond to various economic stimuli.

In order for economic forces to be represented in a realistic and understandable manner, simplifying assumptions are invoked by economic theory. Economic theory assumes that human behavior is rational. This assumption allows the further assumption that economic agents strive to maximize returns. Furthermore, the assumption is made that price[3] is the means of allocating resources and production.

The market determined price of farmland gives a measure of its economic value.[4] Barlowe (1978, p. 323) indicates that economic value incorporates the components of utility, scarcity and being appropriable. Market value thus is a function of the property rights and economic as well as social benefits attached to a particular property. Property rights are exchanged as a means of determining the use-value of farmland and transferring present and future benefits among market participants. The exchange process involves supply and demand forces interacting in a uniquely structured farmland market. Buyers and sellers function in the market largely on the basis of their interpretations of use-value and perhaps exchange value. As a result, numerous economic and social factors enter into the price determining process.

Supply and demand forces are explained by production theory, the theory of economic rent and institutional economics. Production theory provides insight to the transformation of land to food commodities. Therefore, land values can be explained in

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[3]Price refers to the outcome of a specific transaction where a property is exchanged for a specific amount of money.
[4]Value is likely to differ from price in a nonperfect market. Buyers and sellers interact in the market to establish a transaction price largely on the basis of their subjective estimates of value. This study incorporates estimates of value which are based on highly aggregated transactions data.

terms of the product and input prices associated with the transformation process. The rent earning capacity and the process of discounting this rent to present value terms expresses a relationship between the flow of economic benefits and their stock value. As well, the economic processes that underly distinct economic forces are subject to structural and behavioral elements. Institutional economics is a body of knowledge concerning the social origins of economic and non-economic forces which might function in the farmland market.

These distinct economic concepts are discussed individually. However, they must be recognized as highly interrelated. The theoretical concepts are developed in this chapter as a means of describing the fundamental forces operating in the market for farmland. However, the nature of the relationships between these forces is the feature that may provide major insight into the forces leading to changes in farmland values.

B. Supply and Demand

The fundamental concepts of supply and demand provide price-quantity relationships that reveal desires to acquire or dispose of goods. Supply and demand interact in a market environment to determine the prices by which goods are allocated and consumed. Economic theory suggests a number of determinants of supply and demand forces.

In theory, changes in quantity demanded are inversely related to price and thus describe movements along the demand function. Incomes, population levels, prices of related commodities, tastes and preferences act as shifters which determine the level of demand. The elasticities of the demand function describe the response in quantity demanded relative to changes in price, prices of substitutes and complements as well as to changes in income.

The supply function of a good indicates that increased quantities are supplied in response to price increases. The determinants of supply are generally taken to include firm goals, technology, commodity prices, prices of factors of production and the number of producing firms. A more specific look at the land market reveals factors that may influence the incentive to sell land.

Prices at which goods and resources are allocated represent an interaction between the forces of supply and demand. Price usually adjusts to the point where supply and demand equate, thus clearing the market. Price adjustment activity is largely determined by the nature of the market and the good being exchanged.

The traditional view of agricultural markets in a free enterprise economy has been one of perfect competition. This perception of many buyers and sellers, homogeneous goods and complete market knowledge is not necessarily valid for farmland markets. Farmland is a heterogeneous good with limited buyers and sellers. The most distinguishing features of farmland are its immobility and permanence. Each land transaction tends to be unique with respect to the nature of the land and its localized market. Accordingly, the supply and demand forces are likely to be influenced by long run perspectives applied in very localized markets.

The conventional perspective of the demand for farmland is that derived from the demand for food and fibre products of the land. Consequently, farm income influences farmland values through the capitalization process. Many other factors have been emphasized in the analysis of the demand for farmland. Barlowe (1978, p. 49) suggests that population is the dominant factor in the overall demand for land. Population increases create an increased demand for land. In this view, the interrelated effects of different types of land and productivity (of land) must be acknowledged. Renne (1947, p. 30) emphasizes the significant influence of technology on the demand for farmland through changes in land productivity, profitability and use.

Barlowe suggests supply to be the "quantity of goods or resources available for use" (1978, p. 21). The supply of land includes a number of more specific supply concepts. The physical stock or existence of the land resource is a fixed amount limited by the earth's resources. However, the economic availability of the total stock of farmland may be augmented by capital as well as other productive inputs. Furthermore, changing demands for farmland due to changes in output prices and technological change will have an influence on the available stock of farmland. The total supply, that is, the economic stock of farmland, therefore, is not a fixed amount since supply changes in response to changes in the highest and best use of a property. Normally only a small portion of the stock of farmland is transferred through sale in a given time period. The

marketed supply of farmland is a schedule that represents the quantity of land offered for sale at different price levels. Marketed supply results from sellers' responses to economic stimuli, particularily that of use-value. Use-value relates the supply response to physical characteristics, economic forces, institutional forces and technical factors (Barlowe 1978, p. 26). Price-quantity changes thus reflect movement along the supply schedule. Factors such as more attractive off-farm opportunities for investment and employment are shifters of the supply schedule. The responsiveness of marketed supply to economic stimuli might be reduced by institutional forces such as a stong psychological attachment to farmland.

Numerous forces affect the agricultural use of land and thus influence the demand for farmland. Demand shifts may cause price adjustments which in turn may cause adjustments in supply. If market supply were not responsive to price adjustment, demand shifts alone would determine the extent of price adjustment. Both demand oriented and supply oriented adjustments incorporate behavioral responses founded in production theory, the theory of economic rent and institutional economics.

C. Production Theory

As suggested by the concepts of derived demand and market supply, use-value is a major determinant of demand and supply forces. Production theory analyzes the productive characteristics of land in relation to other inputs. In effect, this perspective involves an evaluation of the adjustments made by producers to changing economic forces. Production theory, then, develops relationships to determine the allocation of land (as well as other inputs) among alternative uses based on economic reward.

Land is an input to a production process which provides food and fibre commodities. This input-output relationship can be expressed as a technical relationship involving a production function which varies with the quality and quantity of factors, the state of technology and the nature of the output. The specification of a production function enables specification of the associated cost function of the producing unit and thus enables such a unit to maximize net returns through the optimal allocation of land as well as other factor inputs. The nature of the production function is largely conceptual and often such functions must be assumed to exist since the coefficients are not always

easily ascertainable.

When factor and product prices are known, an optimal allocation of resources may be achieved which results in a profit maximizing level of output. An underlying technical feature of the production relationship which characterizes agriculture is the operation of the law of diminishing marginal returns. Adding a variable factor to a factor which is fixed in the short run due to its "lumpy" nature eventually induces diminishing marginal physical product. Accordingly, the optimal allocation of factors would be at that point where the marginal factor cost (MFC) equals the marginal value of the product (MVP) since profits would be maximized. If variable inputs are added to the point where MFC exceeds MVP, profits begin to diminish.

The demand for land is a derived demand function and is expected to be a function of farmland prices, product prices and other input prices, assuming a constant level of technology. If the market supply of land is completely inelastic, demand shifts alone account for the price variation. The demand schedule for farmland as an input in the production process is given by the MVP schedule for this input.

Production theory may also be applied to explain the market supply of farmland. Land prices, commodity prices and the prices of factors of production likely influence the incentive of landowners to sell land. The supply function would thus express the willingness to sell farmland at different prices for farmland.

D. Theory of Economic Rent

Production theory assumes that a rational producer applies the concept of marginality to achieve optimum return to resources. The level of optimal return is substantially affected by the productive capacity (or productivity) of the land. By introducing the concept of economic rent, the productive aspect of land is related more fully to the forces of supply and demand.

Under conditions of scarcity (that is, full use) more productive land would have a high MVP. Less productive land would have a lower MVP. In effect, the returns to higher quality land are greater than are those to lower quality land. The economic returns to farmland reflect total returns less total costs. Superior land can achieve higher economic returns due to productivity (quality) and location factors.

Soil fertility was initially discussed by Ricardo as a factor determining the economic return to land (Barlowe 1978, p. 176). His argument concerned the increased costs of capital and labor needed to gain a specific level of output from less fertile land. The productive differences between two qualities of soil yield an increased economic return to the owner of superior soil when the same capital and labor is applied. Land of higher fertility is a scarce resource which provides added returns over production costs which accrue to the owner as economic rent.

Von Thunen argued that the advantageous location of particular agricultural land can provide savings in transportation costs which in effect add to the economic rent of the land (Barlowe 1978, p. 168). This argument can be extended to reflect the advantage of location for utilization. Accordingly, a higher-valued and thus better use which results from a preferred location would provide greater economic returns to the land.

The expectation of economic returns to farmland as determined by productivity and location is capitalized to reflect the present value of these benefits. The present value .of the expected returns influences the desires of buyers and sellers since this value is often interpreted as land value. The capitalization of economic rent into land values assumes known levels of rent, knowledge of the number of time periods such rent is expected and an appropriate capitalization rate. These requirements impose many limitations on the application of this theory as a means of determining market value for land. The fluctuations in economic rent caused by fluctuations inherent in agricultural production are difficult to incorporate into the capitalization process. Despite these limitations the present value of expected economic returns to land is a major determinant of market value.

E. The Determination of Present Value

Participants in the farmland market exchange rights involving the future flow of returns to land. Expectations of returns to land are incorporated into both the marketed supply and the market demand of farmland. Consequently, the market value of a property equals the present value of the expected future flow of net returns. The capitalization process is the means by which future flows of revenue are discounted to present value.

The future flow of net returns is discounted to its present value for two primary reasons. First, to reflect individual time preferences and second, to reflect opportunity cost considerations. Technically, the discount rate is the reciprocal of the number of years of expected returns it would take to equal present value (Reynolds 1966, p. 32). As well as accounting for the time preference for money, the discount rate may also be adjusted to account for the magnitude of current returns, an allowance for risk and uncertainty as well as for expected changes in current returns and reversion value.

A number of procedures have been applied in estimating the present value of farmland from expected future revenue flows. The capitalization formula can be specified with the following variables: V is the present value of farmland, A denotes the annual economic returns to land, and r is the discount rate. The present value of a future return in a particular year is:

$$V=A_0/(1+r)^0 \qquad 2.1$$

The present value of a series of returns is:

$$V=A_1/(1+r)^1 + A_2/(1+r)^2 \ldots\ldots A_0/(1+r)^0 \qquad 2.2$$

The present value of a series of uniform returns is:

$$V=A/r[1-1/(1+r)^0] \qquad 2.3$$

The present value of a series of uniform returns over an infinite time period is:

$$V=A/r \qquad 2.4$$

The present value of a series of returns expected to grow at a rate g is:

$$V=A(1+g)/(1+r) + A(1+g)^2/(1+r)^2 \ldots\ldots\ldots A(1+g)^0/(1+r)^0 \qquad 2.5$$

The present value of a series of returns expected to grow at a rate g over an infinite time period when r>g is:[5]

$$V=A/r-g \qquad 2.6$$

F. Institutional Considerations

The market value of land also reflects forces in addition to the prescribed economic constructs noted above. Market behavior is composed of forces that have a social origin resulting from the interaction of people. A rational producer applies the concept of marginality in order to maximize net returns. This behavioral response is

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[5] See Van Horne (1977, pp.22-23).

applicable in a competitive environment where profit maximization is assumed to prevail.

In the context of studying farmland market values, recognition of the structure and function of institutions that interrelate with the farmland market is important. Institutions can be viewed as the rights achieved by collective action. As a result, institutions have economic, social and legal natures which reflect the manner in which they evolved.

Human relationships were incorporated into the analysis of economic forces in work by Commons. These relations were embodied in sets of rules which defined parameters for behavior. These rules were defined by Commons as institutions, "collective actions in control, liberation and expansion of individual action" (1950, p. 21). As a means of economic analysis, Commons emphasized the willingness of individuals to participate in economic activity as well as the dynamic nature of collective action. As human relationships change, values change, such that institutions relate to economic markets in a dynamic manner. Institutional economics thus recognizes social, legal, and historical as well as economic forces.

The fundamental institutions in the farmland market are the rights of private property. Commons states: "in modern capitalism the most important stabilized economic relations are those of private property" (1950, p. 21). As Barlowe indicates "property rights play a major and omnipresent role in determining what people can or cannot do with land resources" (1972, p. 374). The property rights associated with farmland have evolved in a legal framework. Ownership is the highest level of rights in property and provides the greatest level of freedom with respect to the utilization of land. Property rights are also perceived as commodities that can be exchanged in a market. Ownership, in this case, allows for the transfer of specific rights. The essence of market value is the value determined for the ownership rights of a property.

In some circumstances, public interest and private property rights may be opposing forces, particularily where the good of the public is not achieved by private interests in property. With respect to agricultural land, public interest embodied in the Anglo-American tradition integrated agriculture into a market oriented economy to the extent that farmland became an exchange good (Parsons 1974). A recent focus of public interest in agriculture has been toward securing and maintaining a food supply.

Agricultural policy may thus affect the farmland market. Agriculture policy has tended to involve programs to encourage the use of improved technology as well as concessional credit and programs to reduce income instability or enhance income levels. These programs may have had varying degrees of influence on the price of farmland.

Other government programs may affect the farmland market through the mechanisms of taxes and other features of national economic policy. Tax strategies available to agricultural producers and landowners may have attracted nonagricultural investment into the agricultural sector. Policies affecting factors such as economic growth and levels of taxes contribute to an economic environment which may affect buyer's and seller's expectations in the land market.

Institutions such as education and the family may also influence market behavior. These institutions yield behavior responses that are based on nonmonetary incentives which ultimately have economic consequences in the farmland market. A strong behavioral attachment to farmland might tend to reduce the incentive for landowners to sell farmland. Barlowe indicates that families provide a basic incentive for land use and development (1978, p. 359). As well, education is a foundation for attitudes and aspirations that are reflected in market behavior.

G. Summary

Economic theory gives a basis to understanding the functioning of the farmland market. There are limitations to this purely economic perspective and the interrelated nature of human relationships to market forces must be acknowledged. A further body of knowledge is available through the analytical and empirical contributions of the literature concerning farmland values. Chapter Three provides a review of this literature in order to outline specific forces that may affect the farmland market.

III. Literature Relating to the Farmland Market

A. Introduction

There is a large body of literature which provides both analytical and empirical contributions to the knowledge of land values. Predominantly from the United States, this work evolved in response to observed phenomena in the land market. Prior to World War Two, land values were considered to be consistent with farm incomes. This relationship suggested that land values were equivalent with the capitalized value of expected productive returns. As a result, early empirical work largely consisted of explaining factors which affected returns, such as soil quality, yields and distance from market.

During World War Two, farm prices and farm incomes advanced steadily while increases in land values appeared to lag behind. Following the war, increases in farm incomes levelled off and land value increases fell only slightly. During the mid 1950's, in both Canada and the United States, land values followed an upward trend while net farm incomes declined. This divergence between rising land values and declining farm income became the major phenomenon discussed in the literature. Starting in the mid 1950's and continuing into the early 1970's, the literature focused on the many factors that influenced land values and thus could aid in explaining the observed divergence.

Scofield (1957) attempted to sort the many interrelated forces influencing land values. In a conceptual argument he identified economic, institutional, behavioral, national and regional forces that interact in the land market. He emphasized that these factors are economic in nature even though they do not conform to traditional economic analysis. Some of the specific factors identified by Scofield include inflation, population increases, government programs, technology, farm enlargement and nonfarm demand for land. A large amount of the empirical work initiated in the 1960's concentrated on these factors.

The format of this literature review includes discussions on both conceptual and empirical analyses in an interrelated manner. The various arguments, concepts and empirical findings are organized according to major areas of focus in the study of farmland values.

B. Incomes and Returns

Following World War Two, the earlier traditional relationship between land values and farm income attracted increased attention. Larsen (1948) defined a "warranted" value for land that was tested against actual values. The warranted .value was designed to represent the capitalized value of net returns under conditions of perfect knowledge. These seemed consistent with actual land values up to 1915. Following that point, discrepancies occurred which were explained by lags in the response of the warranted value to economic changes. Just prior to 1948, divergent trends developed between the two measures which prompted Larsen to suggest that a continuation of such a trend would cause future land prices to be excessive.

Larsen's suspicions never materialized as United States' land prices declined in the early 1950's (Brake and Melichar 1977, p. 441). However, a definite divergence developed between land values and farm income in the late 1950's that prompted long term interest in determining the actual factors affecting land values. Renshaw (1957) felt that gross farm income could be used as a means of predicting land values Using time-series data for the period 1920 to 1953 and regression models, he found gross farm income to be significant in determining land values. However, a trend variable was also significant. Consequently, factors such as technology and nonagricultural demand were suggested as the forces represented by the trend variable.

Heady and Tweeten (1963) analyzed aggregrate time-series data for the United States from 1914 to 1960, excluding the years from 1942 to 1945. Five hierarchies of hypotheses were specified and one variable was chosen to represent each level in order to minimize statistical problems. All income variables were lagged one year to reflect the likely nature of response of the farmland market. The income variable with the best statistical results was the one that most closely measured the residual to land (gross farm income less all operating and labor expenses and all asset costs except that for farmland). The influence of increasing farm size was concluded to be the major cause of increasing farmland values.

Roehle (1971) as well as Kraft, Fields, Yeh and Romain (1980) have provided time-series studies of Canadian farmland markets using single equation regression models. Roehle analyzed the Manitoba, Saskatchewan, and Alberta farmland markets over

the time period from 1928 to 1969. Future expectations of returns were assumed to be represented by the observed trends in crop receipts per acre. The author concluded that total receipts per acre lagged one year and technology[6] were the major determinants of land values in these markets. Kraft, et al. studied aggregate data for western and eastern Canada. Cash receipts per acre lagged one year and the lagged dependent variable were found to be factors determining the prices of farmland and buildings. Lagged farmland prices were used to represent expectations of future changes in price.

Scofield imputed a residual return to farmland and service buildings using aggregate United States data. He acknowledged that total farm incomes were not increasing sufficiently during the period from 1955 to 1964 to support observed land values. However, Scofield did find that land returns per acre had increased substantially (1965, p. 45). He argued that increases in returns to all factors of production exceeded increases in income to farm operators. Scofield reasoned that increasing farm sizes had reduced the cost of management and labor, and thus greater economic returns accrued to farmland.

Melichar (1979) as well as Gray and Prentice (1980) investigated the concept of returns to productive assets more recently. From aggregate United States data, Melichar observed returns to productive assets rising at a faster rate than their value (1979, p. 1085). He concluded that growth in the returns to assets explains the real capital gains associated with increasing land prices. Gray and Prentice, however, found the return on productive assets for a specified segment of large productive Ontario farms had declined over the late 1970's (1980, pp. 84-85). They suggested that earlier land price increases may have been prompted by increasing returns to assets. They concluded, however, that the expectation of continued land price increases is a dominant market force leading to substantial increases in farmland prices while returns to productive assets had declined.

The relationship between productive returns and market values was investigated by Crowley (1974) and Lee (1976) from a capital budgeting perspective. The traditional

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[6] The influence of technology was represented by dummy variables which were introduced into the regression model to measure changes in the slope and intercept of the farm income explanatory variable during a period of boom in farm technology from 1955 to 1969. The author hypothesized that this period of economic boom in agriculture might cause a structural shift in the parameters of the model.

present value capitalization formula was felt by these authors to be somewhat limited in determining an actual rate of return or an actual land value. Crowley adapted the traditional formula to include expectations of trends in returns and in appreciating land values. Lee expanded the model to include factors that might affect income expectations. The sensitivity of bid price to a number of factors was tested. Lee concluded that expected net income, expectations regarding inflation and terms of financing were significant variables affecting farmland prices.

C. Government Programs

Government programs may influence returns to land. Such programs include direct payments to producers, price support programs, acreage allotments[7] and in some cases programs which control production.[8] In addition, concessional credit programs may increase the demand for farmland if increased credit availability and favorable credit terms enable increased bid prices.[9] Scofield (1965, p. 51) distinguishes the effects of government programs on the basis of how much of the benefit is capitalized into land values. For the period from 1955 to 1964, he concluded that there was no significant relationship between increased government payments in the United States and land values. However, acreage allotments acquired considerable value which became capitalized into land values. Seagraves (1969) found the market value of tobacco allotments to be highly significant with respect to land values.

Reinsel and Krenz (1972) identified factors that would be expected to affect the distribution of program benefits among factors of production. These included the nature of program benefits, the relative levels of supply elasticities of inputs and the alternate uses available for inputs. They argued that land is likely to receive only a portion of any benefits from government programs since these are shared with other inputs.

Roehle (1971) investigated some of the effects of concessional credit on farmland values. Variables representing the Farm Credit Corporation's interest rate and

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[7] Acreage allotments applied in the United States effectively limit the output of a particular commodity by restricting the use of the land input. The returns to alloted crops are typically higher than those of alternative crops. Land, being the fixed input, receives an increased economic residual which is capitalized into land value.
[8] Supply management programs may affect land prices if quota transfer becomes tied to farmland and building transfers.
[9] Favorable lending terms would include lower downpayment requirements, reduced interest rates and longer terms of payment.

maximum lending limit were included in time-series regressions of farmland values for two Manitoba crop reporting districts. Neither of these variables were statistically significant. Kraft studied the concept of credit availability by analyzing the effects of annual disbursements by Farm Credit Corporation and Manitoba Agricultural Credit Corporation on average Manitoba farmland values. Between 1946 and 1972 this variable was statistically significant and its size indicated that every $1 million of credit disbursed by these agencies generated Manitoba farmland price increases of $0.53 per acre (1974, p. 15).

D. Technology

In the mid 1960's, government programs and technological advance both received considerable attention in the American literature relating to farmland values. Chryst (1965) generated a conceptual analysis of the independent and joint effects of technology and income supports. Technological advance in agricultural production typically results in increased output. Accordingly, when a given demand function for agricultural products is inelastic, the increased output leads to a decline in revenue. The joint effect of technological advance and price supports, however, will be to put upward pressure on land values since the price support contributes to economic rent as well as reduced risk. The importance of the joint effects of technological advance together with government programs is confirmed in work by Reynolds (1966) and Reynolds and Timmons (1969).

Herdt and Cochrane (1966) used an index of productivity to represent technological change in a simultaneous equation model. They found this variable (which was however highly correlated with an urbanization variable) to be the major influence on farmland prices. Chavas and Shumway (1982) found technological progress to be a major source of rising farmland values in five Iowa crop reporting districts. Represented by a corn yield variable, technology was included in an analysis of pooled cross-sectional and time-series data. It appeared that technology was interrelated with commodity specific and location specific influences on land values.

Roehle (1971) included a time trend variable which he argued could represent technological advance in an analysis of time-series data from the Manitoba, Saskatchewan and Alberta land markets from 1928 to 1969. This variable did not prove

to be statistically significant in the regression analysis. However, dummy variables were included in the regression to measure the effects of a farm technological boom during the years 1955 to 1969 on the explanatory variable measuring income. Improved statistical results were obtained allowing Roehle to suggest that technological advance was a moderate determinant of farmland values.

Kraft noted that productivity increases may reduce costs as well as induce economies of scale. He also used a trend variable to try to account for this influence. This variable was found to be statistically significant in the Manitoba farmland market from 1946 to 1972. The analysis of this time period revealed that farmland values increased $ 1.37 per acre every year in response to the trend variable (1974, p. 15).

E. Farm Enlargement

Improved technologies are adopted at different rates such that economic gains are achieved by early adopters. The suggestion has been made that these gains are likely to be capitalized into the value of land as the innovator bids up land prices to enlarge operations. Heady and Tweeten (1963), Tweeten and Nelson (1966), Tweeten and Martin (1966) , Reynolds and Timmons (1969) as well as Klinefelter (1973) all found farm enlargement to be a major source of farmland value increases in their various studies. Technological progress has led to farm enlargement as cost reducing technologies have induced economies of scale. In many cases, high intercorrelations between technology and farm consolidation variables require that one variable be eliminated from the statistical analysis. Accordingly, a variable representing farm enlargement could include the influence of technological progress.

Montgomery and Tarbet (1968) studied the wheat–pea growing areas of Washington and Idaho to determine if a significant portion of increasing demand for land was from farmers. A cross–sectional survey of land transactions was undertaken to determine the characteristics of land buyers. Farmers with higher than average rates of return and greater wealth were found to be the source of effective demand for farmland.

Raup indicates that 63 per cent of agricultural land purchases in the United States in the year ending March 31, 1977 involved farm expansion activity. The principal means

of these acquisitions was the use of the financial capacity from existing land bases (1978, p. 303).

F. Economic Development

Traditional analysis of farmland values has been directed at the demand for farmland which is derived from the demand for agricultural products. However, the demand for farmland could be viewed as derived from the demand for space in addition to that of food and fibre. Accordingly, the forces of population, economic development and location have been studied as determinants of farmland values.

Raup (1957) identifies elements of economic development which have an influence on the market for agricultural land in the United States. The effects of technological progress on agriculture, urbanization and inflation are considered to be factors of a nonfarm origin. Urbanization is described as an increased demand for farmland for the puposes of space and investment.

Ruttan (1961) constructed regression models to analyze California cross-sectional census data. These models consistently showed that county population was positively correlated to farm real estate values. Reynolds and Timmons (1969) utilized cross-sectional observations of 48 states in the United States. Nonfarm population density was found to be a source of changing farmland values in 1954 and 1959. However, variations in the value of farmland without buildings were not significantly influenced by this variable. Morris (1978) studied the influence of urbanization (population density) on the farmland values of counties in the United States. Elasticities of the response in farmland values to changes in population density were found to vary according to the nature of the particular county. For the counties where corn production was prominent, Morris indicated that urbanization had forced up land values such that production costs were increased.

Magnusson (1979) tested for the effects of private non-resident investment on Manitoba and Saskatchewan farmland values. Two hypotheses were tested using cross-sectional data and regression models. In a cross-sectional study of municipal land prices, private non-resident investment was found to have an influence on the mean land value in both Manitoba and Saskatchewan in 1976. Municipal price data were also used in

models representing regional markets which had high levels of non-resident ownership. The author concluded that in the East Central region of Manitoba, non-resident investors were willing to pay more for farmland. However, in the Interlake and Western regions of Manitoba, this influence was not observed.

Schuh and Scharlach (1966) studied cross-sectional influences on land values in Indiana. They used explanatory variables representing economic growth, spatial shifts in economic activity, property taxes, productivity and population. Similar results were obtained with six single equation regression models and these suggested that land quality, population density, and increased quantities of nonland inputs had significant positive effects on land values. Property taxes and the increasing price of labor (resulting from local industrialization) were found to be significant negative determinants on land values.

G. Expectations and Inflation

The demand for farmland can be expected to be influenced by the interrelated forces of expectations and inflation. Expectations reflect anticipated price changes in response to numerous institutional and behavioral factors, one of which is inflation. Price expectations for farmland are based on an interaction of expectations with the forces of inflation, price changes and real capital gains. Britney (1964) studied the influence of nonfarm factors in the aggregate as well as regional United States' farmland markets. Price expectations based on changes in previous land values were hypothesized to affect the quantity of farmland demanded. Expectations were represented by the lagged dependent variable which assumed that recent prices had a greater influence than the more lagged prices. This variable was statistically significant and the coefficients (which were used to calculate an adjustment coefficient) suggested that farmland purchasers included economic information from a long time horizon into their price expectations.

The lagged endogenous variable (price of farmland) was found to be a significant explanator of variation in current farmland values by Martin (1977) in an analysis of the aggregate United States farmland market from 1910 to 1975. Since both the dependent and the lagged dependent variable were in real value terms, Martin suggested that expectations of continued real land price increases were an influence on farmland values (p. 25). Kraft, et al. (1980) incorporated the lagged price of farmland as an explanatory

variable, hypothesizing that previous cash flow levels were an influence on the current level of investment in farmland and buildings. This variable was significant for both the eastern and western Canadian farmland markets.

Current prices of farmland might also be affected by previous levels of capital gains. Tweeten and Nelson (1966) found variables representing expected capital gains to be significant and negatively related to both farm numbers and the number of transfers in a multi-equation model. Reynolds (1966) estimated expected capital gains using a weighted average of past capital gains. This variable appeared to influence both voluntary transfers and farmland values. Klinefelter (1973) utilized a three year moving average of previous real capital gains as an explanatory variable for Illinois farmland values. This expectations variable for capital gains was determined (in preliminary tests) to be more appropriate than both the lagged endogenous variable and the distributed lag variable. This variable had a significant influence on the index value of Illinois farmland.

Inflationary forces may be distinct elements of expectations which have contributed to structural changes in the farmland market. Pope, Kramer, Green and Gardner (1979) investigated the suitability of previously developed models to the current farmland market. Their intent was to test for structural change since they found the previous models were no longer effective predictors. They found Klinefelter's (1973) single equation model was the best predictor when applied to more recent aggregate United States data. They considered that simultaneous equation models which included elements of market structure from the previous time period were not suitable for the current market. These authors suggest that expectations in an inflationary economy were characteristics of the current market which should be investigated (p. 115).

Reinsel and Reinsel indicated that expansionary monetary policy in the United States had increased the demand for land (1979, p. 1096). They argued that the fundamental effects of inflation on farmland values were through changes in interest rates and in the returns to farmland. Robison (1980) argues that expectations concerning returns differ from those for interest rates. Expectations of higher rates of growth in returns than in interest rates result in real increases in farmland values.

Tweeten (1981) indicates that returns to farmland have increased at a rate similar to that of farmland values in the United States during the 1960's and the 1970's. He

argues that the real rate of return for farmland has remained relatively constant over time, and that the true effects of inflation are increasing economic returns to farmland and increasing interest rates. Real increases in farmland values occur when returns to equity can be expected to grow at a greater rate than interest costs. Tweeten identifies unanticipated inflation, government programs and long term fixed mortgages as factors which might have caused private discount rates to have increased relatively slower than productive returns to farmland and thus contributed to real capital gains for United States farmland (p. 21).

H. Summary

This literature review reveals a large number of factors which have been studied and identified as determinants of farmland values. Factors revealed in most studies of farmland markets include the levels of farm returns, tendencies toward farm enlargement and technological progress as well as government programs. As well, expectations of market participants .particularily with respect to inflation and economic development are relevant factors in current farmland markets. In Chapter Four many of these factors are hypothesized to be economic forces which influence Alberta farmland values.

IV. Hypotheses to Explain Changes in Farmland Values

The conventional wisdom concerning farmland values is that these values "represent" the capitalization of expected returns. Expected returns are discounted to present value. Therefore, factors which affect expected returns to farmland affect the present value. Factors such as technology, inflation and government policy affect perceptions of future returns and thus are likely to affect land values. Market participants might also form expectations of future prices which could induce price changes in the market.[10] Economic theory and the literature relating to farmland values indicate that there are many factors that could exert some influence on farmland values. As a result, market participants are not likely to have complete knowledge of all the relationships between these factors and farmland value changes. This chapter incorporates economic theory and deductive reasoning to develop hypotheses of some of the forces operating in the Alberta farmland market.

A. Expected Productive Returns

Land has value due to its income producing abilities at present and in the future. The land purchaser would be expected to equate the discounted value of expected net benefits with a purchase price. Expected benefits are likely to be a function of the expected returns to land as influenced by commodity and input prices, crop yields, taxes and prospects for improved land use.

Total farm income is generally taken to include the return to all factors of production. The portion of total farm income which may be capitalized into land values could be viewed as the residual after operating expenses, labor, other capital (non real estate assets) and management factors are paid. These economic returns to farmland are typically viewed as productive returns. Expectations of future productive returns to farmland are very likely formulated by reference to current and previous levels of returns. Although they are not easily measured, they may be represented by observable factors. Net farm income measures the income which agricultural producers have to cover taxes, living expenses and investment. However, net farm incomes may not be an

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[10] See Britney (1964, p. 24) or Martin (1977, p. 16) for discussions of autonomous and induced price changes.

efficient measure of variations in the return to farmland.[11] Gross receipts change if there are changes in commodity prices, crop yields and land use, and therefore may be a more precise measure of variations in the economic return to farmland. The aggregate value of rental payments (over the province) may give a proxy measure of the amount producers are willing to allocate to the land resource.[12]

The impact of year to year variations in expected productive returns on year to year changes in farmland values will be tested using variables which measure gross farm receipts, net farm income and gross farm rent.[13] Expectations of productive returns to farmland are hypothesized to be directly related to farmland values. The various proxies for, or measures of, productive returns are anticipated to have varying degrees of positive influence on farmland values.

B. Inflation, Expectations and Real Capital Gains

The stock of farmland is essentially a fixed quantity whose value can be expressed in monetary terms. The purchasing power of the dollar influences nominal farmland values since general price movements change the level of nominal economic returns to land which can be viewed as being capitalized into nominal farmland values.[14] An inflationary economy may also induce real price changes in the farmland market, as market participants form expectations of future price levels for farmland that are motivated by previous levels of real capital gains.

General price movements likely influence input prices, output prices and discount rates in varying degrees. Therefore, inflation could contribute to real growth in productive returns if output prices increase relative to input prices. The capitalization of increased future returns would result in real capital gains. Since private discount rates should account for inflation in order to insure that economic returns do not lose purchasing power, they might be expected to increase in response to general price

[11] See Scofield (1965) for further discussions on land returns and farm income.
[12] Rental payments for farmland are normally made under cash or crop share arrangements. Provincial gross farm rents are not adjusted for the amount of farmland rented. As a result, this measure will be influenced by the amount farmland rented as well as the productive returns allocated to rented farmland by producers.
[13] In the empirical analysis of provincial farmland values, Statistics Canada data measuring provincial aggregates of gross farm receipts, net farm incomes and gross farm rents are used. In the census division analysis, Alberta Agriculture data measuring average gross farm income and average net farm income per farm taxfiler per census division are used.
[14] This capitalization process is described by equation 2.5.

increases. Should private discount rates increase (in an inflationary economy) at a rate similar to increases in economic returns, the capitalization process is not likely to result in real changes in farmland values. However, institutional factors may be responsible for private discount rates not increasing to the same extent as economic returns in an inflationary economy. If interest costs are not fully affected by general price increases, private discount rates may not increase at the same rate as economic returns thus effecting real capital gains.[15] The possibility of interest rates being sheltered from general price increases may arise in the short run from unanticipated inflation, fixed rate mortgages and concessional credit (Tweeten, 1981 p. 5). These institutional factors may allow general price increases to shift wealth from lenders to borrowers as borrowers achieve real capital gains.

When economic returns to farmland increase at a rate greater than increases in private discount rates, real capital gains in farmland might be viewed as discrete adjustments which maintain the real rate of return (current returns to current land values) in equilibrium with the time preference for money and returns from alternative investments (Tweeten, 1981; Melichar, 1979; Robison, 1980). The initial increases in capitalized value of farmland may cause the real rate of return (in farmland) to fall. Since the increased capitalized value is the result of increased future earnings (from farmland), these real capital gains become a component of the real rate of return realized over the life of the investment. As a result, adjustments in the capitalized value of land can be expected to maintain an equilibrium real rate of return (Tweeten 1981, p. 6).

Previous levels of real capital gains in farmland values might also contribute to expectations that real capital gains will continue. Expectations of real capital gains are argued to be self-generating since past gains create the expectations of future gains (Reynolds 1966; Klinefelter 1973; Prentice and Gray 1980). The increased purchasing power from real capital gains appears to cause an increase in demand and further upward pressure on farmland values. These expectations are likely reinforced by preferential tax treatments on capital gains.[16] In an inflationary economy, these expectations reflect attempts to maximize utility (Britney 1964, p. 25) and to hedge

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[15]This capitalization process is described by Equation 2.6.

[16] Preferential tax treatments involve taxation of only 50% of realized capital gains and provisions for postponement of capital gains taxes in cases of intergenerational transfers of farmland.

against inflation by shifting investments to real assets (Martin 1977, p. 17). Despite the possibility of money illusion, expectations of increasing land prices based on previous increases in farmland values (which are not necessarily the result of increasing productive returns to farmland) are likely to have a positive influence on real farmland values.

Since general price increases may have varying effects on output prices, input prices and discount rates, the effect of inflation on farmland values is an empirical matter.[17] However, the combined influence of general price increases and the institutional factors mentioned are anticipated to have a positive influence on farmland values. Accordingly, a variable is developed which might capture the differential effects of general price increases on output prices and interest rates. The variable X10/X11, is a proxy for the relative effects of inflation on the average annual farm prices of agricultural products and mortgage credit costs.[18] Were this variable to reflect the effects institutional factors might have on interest rates, a direct influence on farmland values would be expected. Expectations of continued real increases in farmland values are also hypothesized to influence farmland values. Therefore, variables which measure previous levels of real changes in farmland values are expected to have direct influences on farmland values.

C. Population and Economic Development

A growing population whose income levels are also increasing may generate a number of influences on farmland values. Anticipated growth in population may cause similar expectations for growth in the demand for food and fibre. The derived demand for farmland would increase and be reflected in increased expectations of farm earnings. As well, farmland may be consumed through such nonagricultural uses as housing, industry, commerce and transportation. Population growth leading to these forms of urbanization may generate an increased demand for farmland. If land is consumed, there is a reduction in the stock of farmland, which may thus contribute to the potential for a declining market supply of farmland.

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[17] Should input prices to increase at a rate greater than output prices, the growth rate of current returns would decline. However, if the discount rate is not affected by such price movements, real capital gains would occur. If input price increases affect only the discount rate, real decreases in land values would occur.

[18] This variable is better described in Chapter Five.

Regional economic development and population growth might be expected to generate a higher value to the land resource. Population may shift geographically in response to shifts in economic activity, including those inspired by such land related factors as resource or market location. The immediate effects of economic development are likely localized. However, economic development could have a more significant influence on surrounding farmland which might experience a "ripple" effect from the development activity. Farmland proximate to the area of growth and development is valued higher on the basis of expected future conversion to a higher value use. The growing population associated with economic development could have increased purchasing power, thus increasing the demand for assets such as farmland. Furthermore, landowners selling farmland for nonagricultural use typically become buyers with greater purchasing power in other areas.[19]

The increased economic activity in Alberta during the 1970's has had major effects in most economic sectors apparently including the farmland market. The influence of economic development and the growing population are thus hypothesized to be directly related to farmland values. Accordingly, variables which measure economic growth in Alberta are anticipated to have positive influences on provincial farmland values.

D. Technological Progress

For the agricultural producer, technological progress involves increased output from a given group of resources or fewer resources needed to achieve a certain level of output. The individual producer does not incur the full costs of technological progress, since research, development and extension costs are largely absorbed by society. Producers adopting technological advances experience reduced costs per unit of output and respond to reduced costs by increasing output.[20] Since land is a fixed factor of production, it tends to appropriate the residual from increased economic returns.

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[19] The purchasing activity of farm operators relocating in other areas is likely to be reinforced by rollover provisions to defer capital gains taxes. Effective March 13, 1977, taxes on capital gains as well as recaptured Capital Cost Allowance can be deferred if the farm property is replaced by similar business assets.

[20] Technological change can be viewed as reducing marginal costs. At the producer level, usage of variable inputs is increased. If input and output prices are exogenous to the firm, the optimum output of individual producers and of the industry will increase.

Where total profits might be associated with efforts to increase farm size, producers attempting to maximize profits can be expected to bid for land with expectations of increased returns that are capitalized into their bid prices.

Under conditions of a given (i.e. fixed) and inelastic domestic demand for agricultural commodities and static export demand, the aggregate and longer run effects of technological change reduces net farm incomes (Chryst, 1965; Reynolds, 1966). The individual producer, however, only recognizes the short run effects of increased productivity. The individual faces an elastic demand curve, therefore, gains in productivity justify higher bid prices for land. As a result, the farmland market can be expected to reflect the benefits of technological advances.

Since cost reducing technologies may become available continuously, producers may anticipate increased levels of future returns. However, not all producers respond quickly enough to benefit from new technologies. The arguement has been made that gains from adopting technology are not sufficiently widespread to be observed in aggregate income statistics (Herdt and Cochrane 1966, p. 248). Technological progress may have a distinct influence on the demand for farmland which reflects the micro impacts of adopting technology. Technological progress is thus hypothesized to have positive effects on farmland values. Variables which might measure technological progress in agriculture could be expected to have positive influences on farmland values.

E. Farm Enlargement

Larger farms are able to reduce unit costs by spreading overhead costs over greater acreage. Farm enlargement is thus argued to be an adjustment process to achieve optimal size, where the economies of size are primarily prompted by technological advance. However the forces of farm enlargement and technological advance may have distinct influences on farmland values. That is, one source of farm enlargement could be distinguished from technological progress as involving a movement along the long run planning curve for the farm firm (under conditions of given technology) in contrast to effects on farm enlargement arising from technological change and involving a downward shift of short run average cost curves.

Economies of size may be initiated by the adoption of labor saving equipment which can result in excess productive capacity of individual producers. Producers are able to bid more for land since the marginal returns from additional land are greater than the average returns of the existing land base. Heady and Tweeten provide an illustration of this phenomenon as follows.

> A farmer owning 160 acres with receipts above variable costs of $50 per acre and with nonland fixed costs of $30 per acre earns $20 as the imputed return to land. Based on a discount rate of 10 per cent, he could pay $20/.10 =$200 per acre for the "home" acreage. But suppose an additional 40 acres is available nearby and he can farm it with existing machinery and other "fixed" discrete inputs. Again the receipts above operating costs are $50 per acre, and other overhead costs are near zero, the return to land is nearly $50. Discounting at the same rate as before, the farmer may pay up to $50/.10 = $500 per acre for the additional 40 acres (1963, p. 409).

As well, increased producer demand for land for expansion can be motivated by the desire to accumulate wealth and might lead to land being sought for this purpose. Larger, established farms likely have superior bidding potential owing to leverage, financial expertise and greater risk bearing ability. For established farms, expanding the land base may be the most desirable means of achieving economic growth. Furthermore, increased competition for farmland may be motivated by the desire of established farmers to assure continued growth over time.

In most farmland markets, "expansion units" sell at a premium over larger tracts of land. This difference presumably reflects gains from economies of size and the financial advantages of land accumulation. Since these economic and even, perhaps, social benefits may increase the demand for farmland, the hypothesis involving farm enlargement anticipates that farm enlargement has a positive effect on the value of land. Therefore, a variable which measures average farm size in Alberta is anticipated to have a direct influence on provincial farmland values.

F. Government Programs

Government activity is a major component of the agricultural environment. National economic policy and agricultural policy have some influence on general price levels, agricultural prices and agricultural production. Public policy is thus linked with the farmland market through its influence on economic returns to farmland as well as through programs which directly affect farmland.

Government activity might generate autonomous price changes in farmland markets through programs involving income stabilization or policies affecting the general economy since these programs may have a direct influence on the economic returns to farmland. However, if the future economic returns to farmland are expected to increase due to public policies, cash flow difficulties may be encountered in the initial years of land ownership.[21] The purchasing ability of existing farm units wishing to expand is relatively enhanced (farm enlargement hypothesis) through ability to endure the initial cash flow deficiencies. Thus, low current returns and high purchase prices may restrict entry by beginning or small farmers. In contrast, some government programs have been directly aimed at improving the purchasing ability of new entrants.

Improved access to credit, reduced risk and a continued government presence in agriculture are activities intended to aid entrants into farming and to aid them to survive an initial period of low current returns. Credit factors may include longer terms than would be available in the private credit market, reduced downpayments and provisions for high risk borrowers, all of which result in a greater number of land purchasers. Another possible factor is the continuation of government programs in agriculture that may reduce the extent of risk and uncertainty facing individual producers and thus attract more entrants to primary agriculture.

Concessional credit programs funded by both federal and provincial governments have improved the purchasing power of those wishing to compete in the farmland market.[22] This funding may be directly capitalized into farmland values since it is a factor which facilitates an increased demand for farmland. Therefore funds disbursed under concessional credit programs are hypothesized to have a positive effect on farmland values. A variable which measures the level of concessional credit extended in Alberta is thus expected to have a direct influence on farmland values.

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[21] Capitalization of increased future returns yields an accelerated increase in the present value of farmland which would be associated with a reduced rate of current returns to asset value. As a result, cash flow may be a problem for new entrants in the initial years until sufficient growth occurs in net returns.

[22] Lower interest rates are also a component of concessional credit programs which in effect reduce a purchaser's discount rate and yield a higher capitalized value. Lower interest rates are recognized in the inflation hypothesis as an institutional factor which allows a greater portion of anticipated future returns to be capitalized into land values.

G. Partial Adjustment to Economic Information

Agricultural producers consider economic information over a period of time when evaluating real estate. Changes in factors affecting the economic return to land may have little immediate effect on farmland values as the response may be spread out over a period of time. Market participants adjust to economic factors over time due to technical, institutional and psychological factors.

In most years the majority of farmland transactions are undertaken in the early spring prior to cropping activity. Once a production program is established, most producers are reluctant to make changes concerning the land resource. After the production process involving land is completed, land transactions take place at an increased level. As a result, a time lag may be introduced into the land market as participants delay their response to economic forces. Similarily, a time delay occurs between the time a transaction is agreed upon and the point in time when the transaction is completed. Due to technicalities involved in transferring real estate, the actual transaction may be based on prices established months previously.

Institutional forces affect adjustment responses in the farmland market through the availability of financing for land purchases. The large amounts of capital required for land purchases are not available to all potential purchasers. Despite the availability of concessional credit there are limitations[23] to obtaining credit for the farmland market. Since potential participants in the farmland market may be unable to bid their desired bid price, farmland values might be prevented from fully responding to current economic information.

The conservative nature of agricultural producers combined with limited experience in land acquisition might further contribute to a delayed response to current economic forces. As a result of these technical, institutional and psychological factors, adjustment to current economic information by market participants may be "sluggish" and thus responsible for autonomous price changes tending to be based on previous farmland values. The hypothesis is made that market participants tend to adjust gradually to annual changes in economic forces and thus tend to rely to some extent on previous

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[23] Both the federal source of concessional credit, the Farm Credit Corporation, and the provincial source, the Alberta Agricultural Development Corporation, have qualifications concerning maximum asset levels and restrictions on maximum loan amounts.

farmland values. Therefore, previous farmland values are expected to have direct influences on current farmland values.

H. Quantity of Farmland Transferred

The marketed supply schedule for farmland represents the amount of farmland offered on the market at various price levels. Since the marketed supply of farmland reflects transactions resulting from changes in the highest and best use of a property, the supply schedule is likely to be responsive to price changes. Furthermore, the supply schedule most likely responds to previous changes in farmland values. Sellers enter the market at different price levels when the minimum selling price for each vendor is different (Herdt and Cochrane 1966, p. 248).

The direction and magnitude of previous price changes are expected to be major influences on the marketed supply of farmland. This applies particularly when prices for farmland are increasing rather than decreasing. When prices are declining, the supply response can be expected to be quite reduced. However, increasing farmland prices may cause the marketed supply to be greater than in the case of declining prices.

The quantity of farmland transferred may be taken as a measure of the marketed supply of farmland. The quantity of farmland tranferred as a measure of marketed supply of farmland is hypothesized to be related to farmland values. Current market supply is anticipated to have an influence on current market values. Therefore, increasing quantities of farmland transferred may be associated with decreasing farmland values.

I. Summary

The hypotheses developed in this chapter relate to various economic factors. Anticipated productive returns, increased future returns, expected real gains, economic development, technological progress, farm enlargement, government programs and previous farmland values are all hypothesized to have direct influences on farmland values. The quantitiy of farmland transferred is hypothesized to be inversely related to farmland values. Chapter Five contains the methodology by which these hypotheses are tested in the Alberta farmland market.

V. Proposed Models, Data and Methodology

A. Introduction

In Chapter Four a number of postulates are deduced to explain changing farmland values. The purpose of this chapter is to restate these postulates in a mathematical form and to develop appropriate statistical methods to test the hypothesized relationships. The objective is to obtain an indication of the sign as well as measures of magnitude and reliability for the factors hypothesized to have influences on farmland values.

This chapter contains discussions of the economic structure of the farmland market, the proposed models for this study and the data and methods of analysis. Data sources, the nature of explanatory variables, statistical estimation techniques, and statistical problems are also discussed.

B. The Structure of Economic Models of Farmland Markets

A model of the farmland market should reflect the underlying causal factors which affect that market if the model is to be realistic. The results and interpretations derived from a realistic economic model have economic significance and practical application. The reason lies in the fact that a realistic model is able to explain the functioning of the farmland market as opposed to merely describing it.

No single specification of a model describing the farmland market has been widely accepted. The economic models for this study are formulated largely through deductive reasoning and the benefit of previous studies. Models hypothesize the influence of various market forces on farmland values. Economic theory provides knowledge concerning the nature of these economic forces. Static equilibrium theory indicates that stable prices and quantities are determined by a balance between production and consumption. Equilibrium prices are thus determined by the interaction between supply and demand forces. However, economic theory is not able to provide knowledge concerning the number of equations to be specified in a model of the farmland market or whether such equations are to be in a linear or nonlinear form. As indicated by Koutsoyiannis, the complexity of the economic relationships, the purpose of the study and the availability of data are all considerations in determining the nature of the

model (1981, p. 16).

Single equation models assume a monocausal relationship. When applied to a farmland market, the equilibrium price is assumed to be a function of a set of independent variables. Since many of the explanatory economic variables might be associated with both supply and demand relationships, single equation models may not be efficient in explaining the complexities of a particular market. If a single equation demand model is to explain all the variations in farmland values, market supply must be assumed to be predetermined. This assumption could be difficult to impose when seeking a realistic economic model. However, the limited ability of a single equation model to explain the functioning of a market may be offset by the ability to generate estimates for most economic phenomenon. Furthermore, single equation models may be the only feasible models when data is limited. Single equation models are also well suited to ordinary least squares (OLS) regression techniques for estimating coefficients.

A system of simultaneous equations is able to reflect buyer and seller behavior through structural components that can be incorporated into the multiple equations of such models. Simultaneous models are, however, founded on the assumption of an instantaneous adjustment to equilibrium. Since economic responses involving land tend to take time, a system of simultaneous equations would likely include lagged variables to explain market behavior.

In a typical recursive model, current supply is determined by previous prices and current price is determined by current supply. Exogenous variables are used to estimate supply which is then used with other exogenous variables to estimate price. Numerous cause and effect relationships can be specified in a recursive model allowing economic phenomenon to be explained by a chain of causation. Recursive models have been developed in several studies of the farmland market (Reynolds and Timmons 1969; Tweeten and Nelson 1966; and Tweeten and Martin 1966). In these studies predetermined supply-oriented variables are used together with exogenous demand-oriented variables to estimate value per acre. Decisions concerning current supply must be made exogenously of current price. Therefore, current price is assumed to have no influence on current quantity. Such an assumption is argued to be valid for farmland markets because producers are reluctant to make changes in their land base

once a production program has been initiated. As well, production programs are likely to be initiated before farmland values reflecting economic information for a particular year are known (Tweeten and Nelson 1966, p. 32).

Recursive models are able to provide explanatory models of the farmland market due to their ability to incorporate explanations of the causal process. Furthermore, the nature of these models may allow an increased number of variables to be included without serious statistical problems. Assuming that random components of each equation are independent, parameter estimates can be derived through ordinary least-squares (OLS) procedures. In an empirical analysis the nature and use of recursive models may be largely influenced by data availability.

C. The Proposed Models

Two general models are specified in order to test the influence of economic forces which are hypothesized to affect farmland values at the provincial and census division levels. Several equations are estimated from these general formulations.

The Provincial Model

At the aggregated provincial level, farmland values are hypothesized to be a function of a series of economic variables. An economic model for this market would incorporate the market value of farmland in a relationship with a series of explanatory variables. This functional relationship is expressed in the following general form,

$$V = f(X_1, X_2, X_3, \ldots\ldots X_0) \qquad \textbf{5.1}$$

in which the dependent variable, V, the market value of farmland, is explained by a series of independent variables hypothesized to have causal relationships with V.

A single equation model is specified for the aggregate provincial farmland market largely due to limited data availability. Supply-oriented data, particularily on the quantity of farmland transferred, are not available for sufficient years to be incorporated into a time series analysis at the provincial level. This study formulates two single equation models to accommodate data on a relatively limited number of variables for the period covering 1940 to 1980. The second model observes the time period 1961 to 1980 and incorporates data which were previously not available.

The Census Division Model

A recursive model is formulated to test the influence of those variables which are expected to influence farmland values at the census division level. This model incorporates data measuring the quantity of farmland transferred. Improved explanatory ability is expected with the recursive model as it involves a cause and effect relationship between land transfers and land values. A problem is encountered in using the transfer data aggregated over census divisions since this is available for a limited time-series only. However, pooling cross-sectional and time-series data at the census division level provides an increased number of observations and thus offers a means of dealing with this problem. The technique of analyzing a time-series of cross-sectional data is specifically discussed in the later section on statistical estimation problems.

The recursive model hypothesizes that the market price of farmland is determined by the current quantity of farmland transferred as well as other exogenous variables. The quantity of farmland transferred is predetermined by a functional relationship with a series of exogenous variables. This model would be formulated with the following general form.

$$V = f(\ T;\ X_1,\ X_2,\ X_3,\ldots\ldots\ldots X_6)$$

$$T = f(\ X_7,\ X_8,\ X_9,\ldots\ldots\ldots\ldots X_0) \qquad \textbf{5.2}$$

In this model, the dependent variable V is the market value of farmland, which is determined by the predetermined variable T, and other exogenous variables X_1, X_2, X_3,..... ...X_6 . The dependent variable T, the quantity of farmland transferred, is determined by the exogenous variables X_7, X_8, X_9,.......X_0.

The provincial model is tested on data expressed in both nominal value and deflated terms, and the census division model is tested on data in deflated terms. The empirical data is collected from numerous secondary sources and is aggregated over the province as well as over individual census divisions. The aggregation of data for the provincial model likely eliminates the influence of various regional effects on farmland values. However, these regional influences might be observed in the recursive model along with time-series influences. Both models can be estimated using ordinary least squares (OLS) regression techniques which are discussed in the later section on statistical estimation techniques.

D. Variable Description and Methodology

This section describes data sources, data limitations and methods of constructing variables. Secondary data are used at both the provincial level and the census division level. Problems of a methodological nature which have their origins in the data are also discussed in this section.

The Consumer Price Index (CPI) is used as a variable representing general price changes when the analysis focuses on changes in the nominal value of farmland. This study places emphasis on the analysis of changes in the real value of farmland. Consequently, the average annual CPI serves an important role as a deflator of price, income and cost data in adjusting these to constant 1971 dollar values. The CPI, published by Statistics Canada,[24] measures price changes over time for a constant basket of goods and services. The index thus reflects changes in the purchasing power (for this basket) of the Canadian dollar. During the entire time period studied (1940 to 1980) the relative weights attached to component goods and services in the basket have been changed in order for the index to remain a relevant measure. A 1971 based index was derived for the entire time period through a procedure which involved shifting the base of the indices as well as splicing data over a number of observations. These adjustments to a 1971 base may be affected by the changes in the weighting.

The variable V1 is the nominal annual average value per acre of farmland and buildings for the province of Alberta.[25] The variable V2 is the nominal average agricultural real estate value at the census division level in Alberta.[26] This variable, V2, represents transfer values for farmland and buildings based on "assurance fund" estimates required on all land transfers.[27] Assurance fund values when aggregated over all agricultural real estate transfers are likely to be influenced by the inclusion of non-arms length transfers.

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[24]CPI data were obtained from Dominion Bureau of Statistics, *Canada Yearbook*, (Annual 1940 to 1970); and Statistics Canada, *Consumer Price Index*, Cat. No. 62-010 (1980).
[25] A series of average per acre values of farmland and buildings was obtained directly from Statistics Canada. These unpublished data provide an estimate of market value based on mail surveys and census farm reports.
[26] These data were obtained from Alberta Agriculture, Resource Economics Branch, *Agricultural Real Estate Values in Alberta*, (1971 to 1980). These estimates were derived from ownership transfer information registered through Alberta Land Titles Offices.
[27] Assurance fund values do not necessarily reflect true market values but serve as approximations. These value data are more fully discussed in Alberta Agriculture, Resource Economics Branch, *Real Estate Value Check, 1977.*

As a result, V2 is very likely to be biased downward.[28] The assurance fund data were available for individual municipalities in the province. Consequently, census division observations were calculated by weighting the municipal observations on the basis of quantity of farmland transferred then taking a weighted average for each of the census divisions. Both V1 and V2 are aggregated estimates which do not represent any specific localized land market. These variables are, however, expected to provide reasonable observations of changes in farmland values over time. Since the variables V1 and V2 measure values for farmland and buildings, the analyses of these variables assume that farmland and buildings are both subject to the same influences. In order to analyze those forces influencing real changes in farmland values, V1 and V2 are deflated by the CPI. The variable DV1 is the provincial average value of farmland in constant 1971 dollars, while DV2 is the census division average farmland value in constant 1971 dollars.

A number of variables representing expected productive returns to farmland are included in the empirical analysis since there are many bases on which farmland buyers might form their expectations. Farm income data aggregated over the province were obtained from Statistics Canada.[29] This source provides the variables of realized gross farm income (X2), realized net income (X3), total gross income (X4) and gross farm rent paid (X6). Differences among these variables involve different sources of farm returns, deduction of input costs and the inclusion of inventory values. The variable X2 measures cash returns from the sale of agricultural products and adds to these returns those from supplementary payments and from home grown produce consumed on the farm. X3 deducts operating and depreciation charges from all farm sources of returns. X4 measures all farm sources of returns and includes adjustment for changes in value of inventory. X6 is gross farm rent paid which provides an estimate of farmer's expenses associated with land and building rentals. When these variables are deflated by the CPI, the resulting variables DX2, DX3, DX4 and DX6 measure returns in real value terms.

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[28] An unpublished research report, Alberta Agriculture, Resource Economics Branch, *Real Estate Value Check, 1977,* (1977) concluded there was a significant amount of undervaluation in assurance fund values based upon subjective checking of these with the assistance of assessors in 14 municipalities.

[29] The data series for 1940 to 1980 are aggregated over all producers in the province. Data was obtained from Dominion Bureau of Statistics, *Handbook of Agricultural Statistics, Part II-Farm Income,* Cat. No. 21-511, 1926-1965; and Statistics Canada, *Farm Net Income,* Cat. No. 21-202, (1970,1980). These data series are estimates derived from quantity and price surveys intended to value agricultural production at the farm gate.

Expected productive returns are likely formulated in response to previous levels of returns. Therefore, the variables described are lagged one year in order to incorporate this behavior pattern into the economic model. The variable DER is a fully distributed lag of realized gross farm incomes (in real terms) observed over three years.[30]

A further series of data obtained from Alberta Agriculture,[31] provides census division observations of both farm income and off-farm income. Since the taxfiler data was collected from individuals only, incorporated farms are excluded from this data source. These annual data are available for each of the 15 census divisions over the time period 1972 to 1976. The variable X21 is the average gross farm income per farm taxfiler per census division. This variable measures returns from the sale of agricultural products. Variable X22 is the total off-farm income per farm taxfiler which measures the net income from wages, salaries, business income, rental income and investment income. X23 is the total net income per farm taxfiler per census division which measures total net farm income and total off-farm income. When analyzing real changes in farmland values, these variables are deflated by the CPI to yield the variables DX21, DX22 and DX23.

The relative effects of off-farm earnings and farm earnings might be observed by constructing the variable DX22/DX21. As DX22 rises relative to DX21, greater returns are obtained from off-farm sources. As a result, demand for farmland may increase if off-farm returns are used to cover cash flow deficiencies in current returns. A rise in off-farm returns relative to farm returns may also prompt an increase in the quantity of farmland transferred if landowners sell farmland in order to pursue higher returns from off-farm sources.

Expected capital gains variables are derived from the data on previous aggregate gains. DECG1 and DECG2 are the variables proposed to measure the expected real capital gains at provincial and census division levels respectively. These variables are calculated from previous capital gains weighted by fully distributed lags. The lag behavior

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[30] The variable is constructed as follows:

$$DER = (3*DX2_{0} + 2*DX2_{0-1} + DX2_{0-2})/6.0$$

[31] Alberta Agriculture, Statistics Branch, *An Analysis of Farm Taxfilers in Alberta 1972 to 1976* (1981). This unpublished report provides income data derived from farm income tax returns for the period 1972 to 1976.

specified in these variables gives the most recent gains the heaviest weighting.[32] The expected capital gains variables are calculated as follows,

$$DECG1=3(DV1_{0}-DV1_{0-1}) +2(DV1_{0-1}-DV1_{0-2}) +(DV1_{0-2}-DV1_{0-3}) /6.0 \quad \textbf{5.3}$$

$$DECG2=2(DV2_{0}-DV2_{0-1})+ (DV2_{0-1}-DV2_{0-2})/3.0 \quad \textbf{5.4}$$

X10 is an index of average annual farm prices of agricultural products for Alberta.[33] The price index relates current farm product prices to those in 1971, the base year. Data series which had earlier base years were shifted to the 1971 base.[34] Since there have been changes in the composition of products which have been used to calculate this index[35] the transformations may have some inaccuracies particularily for earlier data. X11 is an index of mortgage credit costs, obtained from Statistics Canada,[36] to measure changes in the annual cost of interest paid for units of mortgage credit. This series was also derived by rebasing earlier indexes to a 1971 base, which may involve inaccuracies in earlier data. Statistics Canada calculates the mortgage credit index by applying the current interest rate on an adjusted mortgage value. This adjustment accounts for increasing prices of farm real estate; therefore, the index may not be a valid cost measure, particularly for those borrowers who were early entrants into the agriculture sector.

The variable X10/X11 is constructed to serve as a proxy for the relative effects of general price increases on output prices and interest rates. As indicated in Chapter Four, institutional factors such as fixed rate mortgages may contribute to greater growth in current returns than in discount rates. This variable may be able to represent such an influence and is thus expected to have a positive relationship with increasing farmland values.

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[32] A number of different lag specifications were considered in preliminary analyses. The lag behavior specified by variables DECG1 and DECG2 appeared to have the most significant influence on farmland values.
[33] This index was obtained from Statistics Canada, *Numbers of Farm Prices of Agricultural Products*, Cat. No. 62-003, (Monthly). This provides an index of farm gate prices for Alberta, largely derived from monthly reports by farmer correspondents.
[34] This was done by considering a number of observations in each of the data series rather than just the base year. As a result, the procedure used incorporated elements of shifting the base and splicing the data.
[35] The monthly publication acknowledges changes in the computation of the index.
[36] Statistics Canada, *Farm Input Price Index*, Cat. No. 62-004, (Quarterly). This index is one component of the Farm Input Price Index which is designed to measure price changes for a constant basket of farm operating inputs for western Canada.

X12 is a measure of annual population levels in Alberta[37] and is intended to measure the influence of population growth and economic development. X13 is annual gross domestic product per person in Alberta. The gross domestic product data were obtained from Statistics Canada.[38] These were deflated by the CPI and then divided by X12 in order to yield X13 which is postulated to represent nonagricultural influences on the demand for land.

X14 is an index of annual agricultural output per person in Canada. These data were obtained from Statistics Canada.[39] They provide a partial measure of productivity in the agricultural sector. Since output per person does not specifically measure increased productivity resulting from the greater use of capital inputs such as labor saving machinery, variable X14 is not an ideal proxy for technological progress.[40] Further, these data are aggregated over all of Canadian agriculture and thus may not accurately reflect technological advances specific to Alberta agriculture.

Variable X15 measures on an annual basis the total number of Alberta farms and X16 measures the average farm size in Alberta. These variables were constructed using data from the census of agriculture.[41] The census data provide quinquenial observations of total farm numbers and the total area in farms. From these observations, census year observations of average farm size are derived. Since the census farm definition has not been consistent over the period 1940 to 1980,[42] the variables used in the analysis may not be consistent over the time period observed. As well, the complete time-series for these variables was obtained by interpolating and extrapolating between census year observations. Despite these limitations, these two variables provide indications of trends

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[37] Data covering the period 1940 to 1980 were obtained from Alberta Treasury, Bureau of Statistics, *Alberta Statistical Review*, (1978, 1980).

[38] Data covering the period 1961 to 1980 were taken from Statistics Canada, *Provincial Economic Accounts*, Cat. No. 13-213,(Annual).

[39] Statistics Canada,*Aggregate Productivity Measures*, Cat. No. 14-201 (Annual). This index is derived from the system of national accounts to measure labor productivity in agriculture.

[40] These measures (X14) are intended to reflect variations in the quality of the labor force, however technology along with changes in levels of capital investment, capacity utiliization and management skills are likely to have an influence on agricultural output per person.

[41] These census data are available in Alberta Agriculture, *A Historical Series of Agricultural Statistics for Alberta*, (1969) and Alberta Treasury, Bureau of Statistics, *Alberta Statistical Review*, (1978, 1980)

[42] The 1976 definition of census farms specifies holdings with agricultural sales of $1200 or more while the 1971 definition was based on holdings with agricultural sales of $50 or more.

over time in farm numbers and farm sizes aggregated over the province.

Variables relating to concessional credit were constructed for both the provincial level (X17) and the census division level (X27). These variables represent the levels of concessional credit extended in the province. X17 was calculated by combining data for Farm Credit Corporation (FCC) disbursements with Alberta Agricultural Development Corporation (ADC) authorizations.[43] Authorizations may not always result in disbursements; therefore, an element of inconsistency may apply when these two data series are combined. Furthermore, the data were available on a fiscal year basis, and some judgement was exercised in specifying the data to a calendar year basis. X27 was calculated by aggregating loan authorizations (obtained directly from FCC and ADC) for municipalities into census division observations.

The gradual adjustment process by which farmland buyers respond to economic information can be embodied in the lagged endogenous variable. Inclusion of the variable $DV1_{0-1}$ is derived from Nerlove's partial adjustment model,[44] which is founded on the behavioral concept that gradual adjustment takes place due to institutional and technical constraints. This adjustment process becomes habit forming, therefore, farmland buyers tend to rely on previous price levels along with other economic information. The coefficient for this variable provides information concerning the length of the adjustment period.

T2 is the number of acres of agricultural real estate transferred annually and applies at the census division level.[45] Census division observations were obtained by

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[43] Annual data were obtained from, Farm Credit Corporation, *Annual Report and Financial Statements,* (1959-60 to 1980-81) and Alberta Agricultural Development Corporation *Annual Report,* (1972-73 to 1980-81).

[44] Incorporating the partial adjustment model described by Koutsoyiannis (1981, pp. 310-313), the gradual adjustment to changes in the farmland market may be expressed as follows:

$$Y_0 - Y_{0-1} = b(Y^*_0 - Y_{0-1}) + v_0.$$

Where b is the adjustment coefficient which is defined to have a value greater than 0 and less than or equal to 1, which implies the adjustment process is gradual and the adjustment amount declines over time. $Y_0 - Y_{0-1}$ is the actual change in farmland values which takes place. $Y^*_0 - Y_{0-1}$ is the change in farmland values which might have occurred if purchasers responded fully to current information. Since the actual change in farmland values is only a portion of what might have occurred, there is a partial adjustment process and the current value of farmland is influenced by previous farmland values.

[45] These transfer data covering the period 1971 to 1980 are available from the publication, Alberta Agriculture, Resource Economics Branch, *Agricultural Real Estate Values in Alberta,* (1971 to 1980). Transfers of agricultural real estate were defined to include parcels greater than 60 acres in size and valued between \$5 and \$1000 per acre in the period 1971 to 1978 and between \$5 and \$1500 per acre in 1979 and 1980.

aggregating municipal level observations of acres transferred.

E. Statistical Estimation Methods

Selected variables have been proposed as explanators of the variation in farmland values over time. Furthermore, economic models have been formulated as a means of estimating the coefficients for these variables. This section describes the statistical estimation techniques and the statistical criteria as well as limitations that might be encountered in the empirical analysis.

Least-Squares Regressions

Ordinary least–squares (OLS) regression techniques are used to estimate coefficients for both the provincial and census division level models. This is done using a Statistical Package for the Social Sciences (SPSS) econometric computer program. OLS is chosen as the estimating technique primarily because it is a proven method for estimating economic relationships in both single equation and recursive models. As well, this method is relatively easy to understand and apply in linear and nonlinear relationships.

The OLS regression model specified in linear form is as follows.

$$Y = a + b_1X_1 + b_2X_2 \ldots\ldots\ldots b_0X_0 + U \qquad \textbf{5.5}$$

Y is the dependent variable and the X_0's are the independent variables hypothesized to explain the variation in Y. Accordingly, the b_0's are estimated coefficients of the independent variables and these measure the change in the dependent variable resulting from a one unit change in the independent variable. The intercept term, a, is a further parameter of the funtional relationship. The random error term U accounts for the unexplained variation in the dependent variable.

The variation in the dependent variable is thus explained in a functional relationship by explained and unexplained components. Unexplained variation exists in an economic function for numerous reasons. Since variation in an economic variable is explained by many forces, unexplained variation in the dependent variable is likely caused by the omission of explanatory variables. Furthermore, unexplained variation may result from errors due to aggregation, improper model specification, errors of measurement and the random nature of human reponse to economic forces. The essence of OLS is to minimize the sum of the squares of the deviation between the variation explained by the function

and the observed variation in the dependent variable.

By specifying the distribution of values for the error term, OLS is able to estimate the parameters of an economic model. Koutsoyiannis describes assumptions pertaining to the error term as well as the explanatory variables as follows (1981, pp. 55–58).

1. U is a random variable
2. The mean value of U in any particular period is zero
3. The variance of U is constant in each period
4. The variable U has a normal distribution
5. The random terms of different observations are independent
6. U is independent of the explanatory variable
7. The explanatory variables are measured without error
8. The explanatory variables are not strongly correlated
9. Aggregate variables have been correctly aggregated
10. The relationship being estimated is unique
11. The mathmatical formulation is correct

Statistical Criteria

The parameter estimates derived from the economic models are evaluated for their "goodness of fit".[46] Statistical criteria are established to evaluate the explanatory power of a model as well as the reliability of the estimates. Unfortunately, these criteria may tend to be inconsistent with each other since greater explanatory power is very likely achieved at the cost of reduced reliability. The objectives of the research ultimately determine which criterion is of greater importance in the analysis. In this study the economic models have been formulated as a means of contributing to increased knowledge of farmland values. Emphasis is thus given to analyzing economic phenomenon and estimating parameter values. Accordingly, statistical measures which focus on reliability are given greater emphasis in the analysis.

Hypotheses are tested on the basis of a sample population representing the total population. Empirical samples, however, have less than full information concerning the true population. This limitation creates the likelihood of errors in hypothesis testing. Statistical tests thus are founded on the testing of hypotheses which imply statistical

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[46] The term "goodness of fit" refers to the degree to which the economic model describes the empirical data.

significance to a variable or equation.

The standard error of the regression coefficient measures dispersion around the true parameter of the total population. Since errors are expected in the economic models, the size of the error determines whether the estimates are reliable. The standard error test indicates whether an estimated coefficient is significantly different from zero by comparing the standard error with the value of the coefficient. The null hypothesis suggests the true parameter is equal to zero. If the standard error is less than one half the numerical value of the coefficient, the hypothesis is rejected. The standard error test thus implies that the variable is statistically significant and has an influence on the dependent variable. If the standard error exceeds one half the numerical value, the hypothesis is accepted, which implies the variable has no influence on the dependent variable. The standard error test is a general rule providing a quick test for significance of estimated coefficients. However, the levels of significance of parameter estimates are affected by the degrees of freedom.[47] The t-test considers degrees of freedom and thus is a preferred measure of statistical significance in small sample sizes.

Independent variables in an empirical sample have estimated coefficients that are part of a normal distribution around the true parameter. The parameter estimates thus are tested for membership in a normal distribution around the value zero. The Student's t-statistic attaches a probability level to the estimated coefficient being significantly different from zero. The t-statistic is the ratio of the estimated coefficient divided by its standard error and the t distribution considers the level of degrees of freedom.

An F-test analyzes variance as a means of determining the various factors causing variation in the dependent variable. The F-statistic is the ratio of any two independent estimates of variance and thus is used to test the hypothesis that all true parameters are zero. Since this hypothesis implies that the explanatory variables have no influence on the dependent variable, it tests for the overall significance of the regression equation. The F-statistic is also used in testing whether adding a new variable significantly improves the explanation of variation in the dependent variable.

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[47] Degrees of freedom refers to the number of variables that vary freely. Essentially these are the number of linearly independent observations used in calculating the sum of the squares of the deviations. Therefore, when adding an independent variable to an economic model, the degrees of freedom are reduced by one.

The coefficient of multiple determination, R^2, measures the percentage of total variation in the dependent variable that is explained by the independent variables. Since R^2 is expressed as a percentage of total variation, its value lies between 0 and +1. The greater the portion of the variation in the dependent variable which is explained by the model, the higher is the R^2 value.

R^2 is a relative measure which can be increased by including additional explanatory variables into the model. However, the R^2 develops an upward bias when there is no adjustment for the number of explanatory variables included in the model. The adjusted multiple coefficient of determination adjusts for the number of degrees of freedom in a model. Therefore the adjusted R^2 increases with the inclusion of additional explanatory variables only when the sum of the squared deviations is reduced sufficiently to account for the loss in degrees of freedom. Consequently, the highest adjusted R^2 also yields the least variance in the deviations. The adjusted R^2 is thus used in the evaluation of economic models representing Alberta farmland markets in order to maintain a focus on the reliability of parameter estimates.

F. Statistical Estimation Problems

The validity of the OLS estimates as well as the statistical criteria are influenced by the empirical data. Therefore, the statistical results of this study are evaluated with respect to econometric criteria that test for imperfections in the economic data. When the assumptions concerning the error term and the explanatory variables do not hold, the validity of the estimates and the statistical criteria become suspect. Two common statistical problems that originate in the data are autocorrelation and multicollinearity. Furthermore, the pooling of time-series and cross-sectional data as a means of dealing with a problem of too few degrees of freedom raises statistical problems.

Autocorrelation

One assumption of OLS techniques is that the random variables from two successive time periods are independent of each other. Autocorrelation is the statistical problem that results when the random terms are correlated. When autocorrelation is present in an economic model, the OLS estimates have large variances. Therefore, the OLS estimates are less efficient than the estimates derived by other econometric

techniques.

Autocorrelation is introduced into an economic model when explanatory variables are omitted, the functional relationship is incorrectly specified, when the true disturbances are mis-specified (Koutsoyiannis 1981, p. 204). Since time-series data tend to show cyclical movements, true autocorrelation may also be introduced into an economic model.

The most common test for the presence of autocorrelation is the Durbin-Watson Test.[48] The d-statistic is used in testing the statistical significance of an estimated autocorrelation coefficient. The computed d-statistic is compared with computed upper (du) and lower (dl) bounds since the exact distribution of d is unknown. The bounds thus are used to test for positive autocorrelation and can be adjusted to test for negative autocorrelation. When d is less than dl the hypothesis of no autocorrelation is rejected which implies there is positive autocorrelation. When d is greater than du the hypothesis of no autocorrelation is accepted. If d falls between these two bounds the test is inconclusive for positive autocorrelation (Koutsoyiannis 1981, p. 214). The solution to an autocorrelation problem is usually determined by the source of the autocorrelation. Therefore, reformulating the model to include missing variables or an autocorrelation coefficient are two means of eliminating the serial correlation among the errors terms.

Multicollinearity

OLS estimates assume that explanatory variables are not perfectly linearly correlated. A high level of correlation between two explanatory variables introduces the statistical problem of multicollinearity. The problem essentially is in obtaining precise estimates of the separate effects of explanatory variables that are highly correlated. According to Koutsoyiannis, multicollinearity may impair the accuracy and stability of the parameter estimates, but the exact effects have not as yet been theoretically established (1981, p. 233). The statistical criteria used to evaluate the reliability of the parameter estimates might also be influenced since intercorrelated explanatory variables may cause increased standard errors. The high standard errors, therefore, might cause explanatory variables to have reduced statistical significance.

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[48] For a further description of the Durbin-Watson Test and the d-statistic see Koutsoyiannis (1981, pp. 212-216).

Empirical time-series data obtained with respect to the farmland market are likely to be highly correlated due to the influence of economic growth on many of the explanatory variables. A somewhat subjective procedure can be established for dealing with multicollinearity through a selection process that removes highly correlated explanatory variables from the economic model. Accordingly, explanatory variables will not be included when the correlation with another explanatory variable exceeds ± .80 . Furthermore, only one instance of correlation between two explanatory variables exceeding ± .70 will be allowed in a functional relationship.

Pooling Cross-sectional and Time-series Data

The analysis of farmland values at the census division level is undertaken primarily to observe the influence of the quantity of farmland transferred on farmland values. Transfer data at the provincial level are available for the period from 1971 to 1980. This limited number of observations may introduce the problem of too few degrees of freedom into the statistical analysis. However, the census division transfer data can be incorporated into a time-series of cross-sectional observations. The pooling of cross-sectional and time-series data increases the degrees of freedom. However, other statistical problems may be introduced into the analysis.

Census division farmland values include time-series and cross-sectional variations. Explanatory variables thus measure variations over census divisions and over time as well. The models and estimating techniques applied to pooled data impose assumptions concerning the influence of cross-sectional and time-series variation on the slope coefficients and the points of intercept. Therefore, consideration must be given to the appropriateness of pooling data and the reliability of pooled estimates.

There are many models and estimating techniques which might be employed in analyzing pooled data.[49] Unfortunately, the methods which might provide the most refined analysis of census division farmland values are quite complex and not readily available in computer packages. However, covariance models are common in dealing with pooled data and parameter estimates which can be derived through OLS techniques. A covariance model assumes that slope coefficients are constant and that intercepts vary for the cross-sectional and time-series units. Therefore, variations over time and among census

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[49] Judge et al. provide a comprehensive description of these methods (1980, pp. 325-359).

divisions are measured by the variation in intercept points.

With respect to census division farmland values, the covariance model introduces dummy variables to represent the 15 census divisions and the time periods over which data were observed. These dummy variables account for qualitative differences over census divisions and over time by varying the intercept term for the individual census divisions and years. Furthermore, the dummy variables impose fixed values on the variation between the mean intercept point and the intercept for the individual units since random variations between cross-sectional units and between years cannot be incorporated into the model.

The coefficients of explanatory variables may not reflect all of the influence of the particular force represented. This feature occurs since explanatory variables include cross-sectional or time-series components which are likely to be measured by the dummy variables. As a result, the economic interpretations which might be made with respect to an explanatory variable should consider the influence of the dummy variables.

G. Summary

Chapter Five has outlined methodology concerning economic models, variables and estimation methods. A number of economic variables will be tested in the proposed economic models in order to determine those forces having an influence on farmland values in Alberta. Emphasis is placed on achieving realistic economic information which might contribute to improved decision making concerning farmland purchases. Therefore, statistical methods and criteria are oriented towards obtaining explanatory ability and reliability. The variables developed for this analysis are summarized in Table 6.1. Chapter Six will present the empirical results of the proposed models.

VI. Statistical Results

A. Introduction

The general models and variables described in Chapter Five are used to estimate farmland values at both the provincial and census division levels. Various formulations are estimated in order to determine which variables have a statistically significant influence on farmland values and thus add to the explanatory power of an equation. As well, a number of different measures of some explanatory forces are compared to determine which variable provides a superior measure of the hypothesized force. The equations which appear to best explain farmland values are presented in this chapter with their statistical results. Statistical interpretations and economic inferences of the results are made to provide a basis for economic conclusions and economic implications which are developed in Chapter Seven.

The empirical results are presented in two sections. The first section presents results for the time-series analysis of aggregate provincial data. This particular analysis is further broken down into two different time periods based on data availability. These are the period covering 1940 to 1980 and the period covering 1961 to 1980. The second section of the empirical results are from the analysis of pooled time-series and cross-sectional data at the census division level. This analysis is intended to cover the period 1971 to 1980; however, lack of data reduces the number of observations in some model formulations.

Table 6.1 presents the variables which are used in the analyses. The designation, description, and units of measure for the variables are presented to complement the presentation of statistical results. The variable descriptions and units of measure are a particularily important component of both statistical and economic interpretations.

B. Provincial Analysis

The results of models explaining provincial farmland values using value data which are expressed in nominal form are presented in Table 6.2 . These estimates are derived from the general model 5.1 outlined in Chapter Five and cover the period 1940 to 1980. In this table, the equation numbers are presented in the first column, the adjusted R^2 in the

Table 6.1: Identification and Description of Variables Used in the Empirical Analysis.

Variable	Description
CPI	Consumer Price Index (1971=100).
V1	Current provincial value of farmland and buildings ($/acre).
DV1	Real provincial value of farmland and buildings in constant 1971 dollars ($/acre).
V2	Current census division value of farmland and buildings ($/acre).
DV2	Real census division value of farmland and buildings in constant 1971 dollars ($/acre).
X2	Current value of realized gross farm incomes aggregated for the Province of Alberta (millions of dollars).
DX2	Real value of realized gross farm incomes aggregated for the Province of Alberta in constant 1971 dollars (millions of dollars).
X3	Current value of realized net farm incomes aggregated for the Province of Alberta (millions of dollars).
DX4	Real value of gross farm incomes aggregated for the province of Alberta adjusted for changes in inventory in constant 1971 dollars (millions of dollars).
X6	Current value of gross farm rents aggregated for the Province of Alberta (millions of dollars).
DX6	Real value of gross farm rents aggregated for the Province of Alberta in constant 1971 dollars (millions of dollars).
DER	3 year fully distributed lag of realized gross farm incomes aggregated for the Province of Alberta in constant 1971 dollars (millions of dollars).
DX21	Real value of average gross farm income per farm taxfiler per census division in constant 1971 dollars (hundreds of dollars).
DX22	Real value of average total off-farm income per farm taxfiler per census division in constant 1971 dollars (hundreds of dollars).
DX23	Real average value of total net income per farm taxfiler per census division in constant 1971 dollars (hundreds of dollars).

Variable	Description
ECG	3 year fully distributed lag of previous gains in nominal provincial farmland values, representing expected capital gains ($/acre).
DECG1	3 year fully distributed lag of previous gains in real provincial farmland values, representing expected real capital gains at the provincial level ($/acre).
DECG2	2 year fully distributed lag of previous gains in real census division farmland values, representing expected real capital gains at the census division level ($/acre).
X10	Index of farm prices of agricultural products (1971=100).
X11	Index of mortgage credit costs (1971=100).
X10/X11	Ratio of indexes of farm product prices and mortgage credit costs, representing the change in the prices of agricultural products relative to the change in mortgage credit costs (1971=100).
X12	Population of the Province of Alberta (thousands).
X13	Real gross domestic product per person in the Province of Alberta (millions of dollars per person).
X14	Index of agricultural output per person, Canada (1971=100).
X15	Total number of Alberta farms (Individual farms).
X16	Province of Alberta average farm size (acres).
X17	Real concessional credit extended by FCC and ADC at the provincial level (millions of dollars).
X27	Real concessional credit authorized by FCC and ADC at the census division level (millions of dollars).
T2	Quantity of agricultural land transferred at the census division level (thousands of acres).
PT2	Predicted quantity of agricultural land transferred at the census division level (thousands of acres).

second column, the F-statistic for the equation in the third column and the Durbin-Watson d-statistic in the fourth column. The remaining columns report the regression coefficients and standard errors (in parentheses) of the explanatory variables. Standard errors are used in calculating the t-statistic to test whether the estimated coefficient is statistically significant. For the empirical results presented, the reliability of the estimated coefficients are tested with a t-statistic to determine whether the explanatory variable has a statistically significant influence on the dependent variable. The estimated coefficients of explanatory variables which are not statistically significant at the 5 per cent level of significance are indicated by # . This format is used in presenting statistical results at the provincial level. The results of further equations are presented in Appendix B. These results may be referred to in order to provide additional information for statistical and economical interpretations.

Since expected productive returns are subjectively determined by farmland buyers and may not necessarily be a precise economic residual allocated to farmland, Equations 6.01 to 6.03 include different measures of expected productive returns to farmland. These variables all have positive influences on farmland values, significant coefficients and the F-statistics are highly significant. The equation which includes realized gross farm income lagged one year ($X2_{0-1}$)[50] has a higher F-statistic and adjusted R^2 than those which incorporate variables measuring realized net farm income (X3) and gross farm rent paid (X6). This difference could imply that expected productive returns are influenced by components of gross farm income that are not necessarily part of net farm income or gross farm rent. As well, the lagged nature of this variable could suggest that in formulating expectations of future economic returns, farmers consider previous levels of returns (to farmland) in their formulations.

Additional variables are included in Equations 6.04 to 6.07 to represent expected capital gains (ECG), general price increases (CPI) and farm enlargement (X16) forces. Variable X16 measures average provincial farm size and is taken to represent the combined influence of technological progress and farm enlargement.[51] Variable X16 and

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[50] Variables which are lagged one year are denoted by the subscript $_{0-1}$.

[51] Equation B.13 in Appendix B indicates that the variable X14 measuring agricultural output per person is a significant influence on farmland values. As well, there is a high level of correlation between variables X16 and X14 (.82). Since there might be a cause and effect relationship between technology and farm enlargement, the variable X16 is assumed to represent the combined influence of these two forces.

Table 6.2: Estimates of Provincial Farmland Values Using Nominal Value Data, for the Period Covering 1940 to 1980.

Equation	Adjusted R^2	F-statistic	d-statistic	Constant	ECG	CPI	$X2_{t-1}$	X6	X3	X16
6.01	.972	1281	.703	-12.9			.1183 (.001)			
6.02	.949	682	.703	-4.4				2.373 (.090)		
6.03	.712	93	.776	-43.8					.4167 (.040)	
6.04	.957	429	.554	-111.8	3.543 (.240)					.2565 (.023)
6.05	.988	770	.327	-47.2	1.712 (.270)	1.025 (.260)	.0140# (.020)			.0243# (.028)
6.06	.989	876	.430	-59.2	1.377 (.285)	.788 (.217)		.5971 (.250)		.0618# (.031)
6.07	.991	1115	.416	-50.8	2.18 (.201)	1.27 (.110)			-.0634 (.020)	.0374# (.023)

Standard errors are presented in parentheses.
# indicates variable not significant at the 5 per cent level.

variable ECG both have significant influences on farmland values when specified together (Equation 6.04). However, when variables representing expected productive returns and increasing general prices are included in this specification, variable X16 has reduced significance (Equations 6.05 to 6.07). Variable X16 is highly correlated with CPI (r=.91) since general prices and farm size have tended to change together over time. Since these variables have similar trends, CPI may be accounting for most of this influence and X16 accounting for very little. Variables representing expected productive returns may include economic influences that are also measured by other explanatory variables. One reason for increasing farm size is to achieve economies of size which would increase expected productive returns.[52] Increasing general prices also affect the expected productive return variables $X2_{0-1}$, X3 and X6.[53] As a result, the variable CPI may be accounting for the influence of expected productive returns and thus causing the estimated coefficients of the variables $X2_{0-1}$, X3 and X6 to have reduced significance or to be unreliable due to the statistical influence of multicollinearity.

The variable ECG is a three year fully distributed lag of changes in farmland values. Consequently, this variable is influenced by general price changes and changes in the economic returns to farmland.[54] Expectations of capital gains are likely to increase in response to increasing general prices and increases in the current returns to farmland. Therefore, the ECG variable may account for variations in expected productive returns, which would explain the reduced significance of variables $X2_{0-1}$ and X3 (Equations 6.05 and 6.07).

Equation 6.04 may be the most meaningful of the equations presented in Table 6.2 since the explanatory variables describe independent economic relationships which exert an influence on farmland values. Variable ECG suggests that expected capital gains influence farmland values and ECG is likely accounting for the influences of general price changes and changes in the economic returns to farmland. Variable X16 suggests that farm enlargement also has an influence on farmland values.

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[52] The levels of correlation between X16 and X3 (.75), X6 (.76) and $X2_{0-1}$(.85) suggest that farm enlargement is related to these measures of expected productive returns.
[53] This is confirmed by high levels of intercorrelation for the variables $X2_{0-1}$, X3 and X6 with CPI (.98, .98 and .94 respectively).
[54] The levels of intercorrelation between ECG and CPI (.83), $X2_{0-1}$ (.88), X3 (.89) and X6 (.93) would confirm these relationships.

Even though Equation 6.06 provides estimated coefficients for all the explanatory variables which are statistically significant, economic interpretations focusing on explaining the farmland market are limited by the presence of multicollinearity and autocorrelation. Many of the explanatory variables included in these models are highly correlated which discourages economic interpretation since the influence represented by a particular variable may actually be measured by a different variable. Variable CPI has a dominant influence on farmland values as well as the other explanatory variables. High correlations of the variables considered with CPI suggest that general price changes may be a major influence on most of the explanatory variables which measure monetary values. A more comprehensive analysis of farmland values may be achieved by adjusting for this common influence. Consequently, the ensuing analyses incorporate data in real value terms in order to determine the forces which explain changes in real farmland values. As well, the d-statistics in all of the models presented in Table 6.2 suggest the presence of positive autocorrelation. This presence is likely due to similar trends in the data or the omission of important explanatory variables resulting in a systematic pattern among the error terms. When autocorrelation is present, the variance of the random term may be underestimated. Parameter estimates derived from a sample of empirical data may therefore be inaccurate estimates of the true parameter values.[55]

Statistical results from the analysis of real provincial farmland values are reported in Table 6.3. These results are derived from the general model 5.1 proposed in Chapter Five and cover the period from 1940 to 1980. Real provincial farmland values have increased over this period which suggests that forces other than general price increases have had an influence on farmland values. To analyze the sources of real changes in farmland values, data for price, cost and income variables are deflated by CPI. Consequently, variables measuring dollar amounts are expressed in terms of constant

[55] There are a number of methods which may be applied to estimate parameters when autocorrelation is suspected. These methods typically involve transformations of the original data. One of the more popular methods is the first-differences transformation which assumes the autocorrelation coefficient is equal to one. The Cochrane-Orcutt iterative method is another means of dealing with autocorrelation. This method involves transforming the original data by estimating an autocorrelation coefficient. Ordinary least-squares techniques can then be applied to estimate the parameters of an equation which has an autoregressive disturbance. However, there is difficulty in interpreting the economic meaning of variables with these transformations. With respect to this study, a number of the hypothesized factors are already measured in first-difference form. An alternative approach that is used in this study is the logarithmic transformation of the observed data.

1971 dollars. The results presented in Table 6.3 provide an evaluation of the effect of those forces hypothesized to have an influence on real changes in farmland values.

The equations presented in Table 6.3 test the influence of variables representing the forces of expected real capital gains (DECG1), farm enlargement (X16), expected productive returns (DER, DX6 and $DX2_{0-1}$) and a lagged response to information on farmland values ($DV1_{0-1}$). In most cases these models have highly significant adjusted R^2's and F-statistics. However, the d-statistics indicate for many of the models the presence of a systematic influence among the error terms. This result is likely due to the presence of variables with similar trends over the period observed or the omission of important explanatory variables.

With respect to the variable DECG1, declining weights are attached to the real capital gains of three previous years which implies that more recent gains have a greater influence on current farmland values. When tested individually, the DECG1 variable has a significant influence on farmland values (Equation 6.08). However, the low adjusted R^2 indicates that DECG1 has limited explanatory power with respect to changes in real provincial farmland values.

Expected productive returns to farmland are represented by the variables DER, $DX2_{0-1}$ and DX6 . These variables measure realized gross farm incomes ($DX2_{0-1}$ and DER) and gross farm rent paid (DX6) aggregated over the province. The influence of expected productive returns on farmland values may have different distributions over time. $DX2_{0-1}$ being lagged one year assumes that expected productive returns are based on the most recent observation of past realized gross farm incomes. DER involves a fully distributed lag over three observations of past realized gross farm incomes, where more weight is given to the most recent information, implying that anticipations are based on a longer time horizon than one year. DX6 is the current year observation of gross farm rent which assumes that expectations of productive returns emphasize a very current measure of economic returns to farmland. The highly significant F-statistics and adjusted R^2's in Equations 6.09 to 6.11 suggest that all of these variables have an influence on farmland values. Variable DX6, which is the most current measure of productive returns to farmland, explains the least amount of variation in farmland values (Equation 6.11).

Table 6.3:Estimates of Provincial Farmland Values Using Real Value Data, for the Period Covering 1940 to 1980.

Equation	Adjusted R^2	F-statistic	d-statistic	Constant	DECG1	$DV1_{0-1}$	DER	$DX2_{0-1}$	DX6	X16
6.08	.309	18	.092	72.1	3.366 (.080)					
6.09	.807	155	.348	-23.4			.1219 (.010)			
6.10	.785	136	.544	-17.4				.1127 (.010)		
6.11	.325	19	.220	17.45					1.664 (.380)	
6.12	.822	86.7	.270	-16.7	.9646 (.469)		.1108 (.010)			
6.13	.781	67	.541	-14.2	.3805# (.563)			.1078 (.010)		
6.14	.374	12	.098	35.4	1.951# (1.00)				1.051 (.490)	
6.15	.986	1332	1.93	1.44	1.298 (.123)	.9755 (.023)				
6.16	.957	277	.327	-45.3	1.47 (.235)		.0269 (.010)			.1503 (.014)

Standard errors are presented in parentheses
# indicates variable not significant at the 5 per cent level.

Including the variable DECG1 with each of the expected return variables does not noticeably improve the statistical results (Equations 6.12 to 6.14). DECG1 has an increased standard error and reduced significance in these models. However, variable DECG1 and the expected productive return variables are most likely measuring separate influences since DECG1 is not highly correlated with the variables DER (.50), $DX2_{0-1}$ (.60) and DX6 (.65). The expected productive return variables seem to account for most of the variation in farmland values. In these models (Equations 6.12 to 6.14) variable DECG1 accounts for very little of the variation in farmland values, perhaps since the influence of general price changes and expectations is accounted for by the expected productive return variables.

When DECG1 is included in the same model as the lagged dependent variable ($DV1_{0-1}$) the statistical results are superior to all other models (Equation 6.15). Together, these two variables appear to be sufficiently comprehensive to account for most of the explanatory forces influencing changes in farmland values. The lagged dependent variable specifies a dynamic adjustment process which assumes that previous farmland values are an influence on current farmland values. Participants in farmland markets may not respond fully to changes in current economic forces which are acknowledged to have an influence on farmland values. Accordingly, previous economic information, particularly previous farmland values, may determine current farmland values. Variable $DV1_{0-1}$ may therefore capture the influence of a number of economic forces which have had an influence on previous farmland values. When included in the same model as $DV1_{0-1}$ the variable DECG1 may account for expectations of real capital gains that are associated with previous levels of real gains in farmland values. Previous changes in farmland values, therefore, might induce price changes in current farmland values in an inflationary economy.

The estimated coefficient of $DV1_{0-1}$ is (1−b) where b is the adjustment coefficient. Therefore, in Equation 6.15 the adjustment coefficient is calculated to be .0245 . A two tail t−test is applied to determine whether this coefficient is significantly different from both 0 and 1.[56]

[56] The Nerlove adjustment model constrains the adjustment coefficient to be greater than 0 and less than or equal to 1. If the adjustment coefficient were to equal 0, this implies that past prices do not have a significant influence on farmland values. Were the coefficient equal to 1, the most immediate past price is the most significant influence on

[56] The adjustment coefficient is significantly different from 1 at the 5 per cent level and significantly different from 0 at the 15 per cent level.[57] If the 15 per cent level of significance is not accepted, the adjustment coefficient is not statistically different from 0 . This result implies that past prices of farmland are not used as a guide to current farmland values. If the 15 per cent level is accepted, the adjustment coefficient implies that long term trends in farmland values are used as a guide to current farmland values. The low coefficient of adjustment value suggests a very sluggish response to current economic or technical information. However, the adjustment coefficient is likely to be underestimated if other explanatory variables with a lagged response are missing. If such explanatory variables are omitted from the model specification, the estimated coefficient of the lagged dependent variable may measure their lagged response.

Variable X16 measures increasing farm size over the period of observation. In this analysis, X16 is assumed to serve as a proxy for the combined influence of technological progress and farm enlargement.[58] Therefore, as a measure of the influence of economies of size and the substitution of capital for .labor, X16 is likely to be associated with variations in expected productive returns.[59] The reduced significance of variables $DX2_{0-1}$ and DX6 in Equations 6.17 and 6.18 suggests that variable X16 may be accounting for at least some portion of the expected productive returns influence. This exlanation seems particularily applicable to the variable DX6 which explains only a small portion of the variation in farmland values. In Equation 6.16, variable DER has a reduced coefficient and is barely significant at the 5 per cent level when included as an explanatory variable with DECG1 and X16. Since variables X16 and DER are highly correlated (.84), Equation 6.16 does not offer an improved model with respect to economic content.

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[56](cont'd)current farmland values. Therefore, there is a lagged partial adjustment to current economic information when the adjustment coefficient is significantly different from 0 and 1.

[57] The t-statistics for the adjustment coefficient are calculated as follows:

$$t = .0245-0 \; / \; .023 = 1.07$$
$$t = .0245-1 \; / \; .023 = -42.41$$

[58] Equations B.20 to B.22 in Appendix B indicate that variables X16, X14 and X15 are all able to explain a significant amount of the variation in real farmland values. Since X16 is able to explain the greatest amount of variation in real farmland values, it may be measuring the related influences of increasing technology and decreasing farm numbers.

[59]X16 has various levels of intercorrelation with the variables DER (.84), $DX2_{0-1}$ (.82) and DX6 (.44).

The estimated coefficients of DECG1 and their statistical significance noticeably increase in Equations 6.16 to 6.18. The reduced coefficients of the expected productive return variables could imply that the DECG1 variable accounts for more economic influences, and thus have increased statistical significance.

The lagged dependent variable is included as an explanatory variable along with variables X16, DECG1 and a variable representing expected productive returns in Equations 6.19 to 6.21 . As previously discussed, $DV1_{0-1}$ may account for the influence of many economic forces.[60] This feature could explain the reduced coefficient estimates for variable X16 and the reduced significance of the expected productive return variables when specified in the same model. The estimated adjustment coefficients derived from the coefficients of variable $DV1_{0-1}$ are all significantly different from both 0 and 1.[61] The adjustment coefficients are increased when X16 is included in the model. Since behavioral responses to explanatory variables may be lagged in nature, variable X16 may account for the lagged response in farm enlargement to the influence technological advance. This could cause the adjustment coefficient to increase since X16 may capture some of the lag behavior in these equations. The estimates of the adjustment coefficients suggest that behavior in the farmland market involves a lagged adjustment to economic information which is consistent with the hypothesis that farmland values in previous years are used as a guide to current values. DECG1 is statistically significant in all three of these models (Equations 6.19 to 6.21). This variable may capture some portion of the influence of expected productive returns as well as expected capital gains.

Equations 6.22 to 6.24 are logarithmic transformations involving nonlinear specifications of Equations 6.19 to 6.21.[62] The estimated coefficients of the explanatory

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[60] This would be confirmed by the high levels of intercorrelation between variable $DV1_{0-1}$ and DER (.89), $DX2_{0-1}$ (.86) and X16 (.95).

[61] The t-statistics for the coefficient of adjustment derived from Equation 6.19 are:

$t = .2566 - 0 /.066 = 3.89$
$t = .2566 - 1 /.066 = -11.64$

The t-statistics for the coefficient of adjustment derived from Equation 6.20 are:

$t = .2500 - 0 /.061 = 4.09$
$t = .2500 - 1 /.061 = -12.30$

The t-statistics for the coefficient of adjustment derived from Equation 6.21 are:

$t = .2702 - 0 /.057 = 4.74$
$t = .2702 - 1 /.057 = -12.80$

[62] The general model is a nonlinear function which has the following logarithmic transformation:

$\ln Y = \ln a + b_1 \ln X_1 + b_2 \ln X_2 ....b_0 \ln X_0 + u.$

The dependent variable Y, the constant term a and the explanatory variables X's are transformed to natural logarithms.

Table 6.3 (continued):Estimates of Provincial Farmland Values Using Real Value Data, for the Period 1940 to 1980.

Equation	Adjusted R^2	F-statistic	d-statistic	Constant	DECG1	$DV1_{t-1}$	DER	$DX2_{t-1}$	DX6	X16
6.17	.951	242	.326	-45.3	1.476 (.284)			.0166# (.010)		.1634 (.015)
6.18	.949	229	.279	-47.9	1.607 (.289)				.1308# (.150)	.1809 (.009)
6.19	.991	1007	1.67	-12.2	1.39 (.109)	.7434 (.066)	.0013# .010			.0493 .011
6.20	.991	1021	1.55	-11.78	1.425 (.122)	.7500 (.061)		.0033# (.010)		.0504 (.011)
6.21	.991	1047	1.75	-14.3	1.297 (.122)	.7298 (.057)			.0705# (.060)	.0488 (.011)
6.22[1]	.987	688	1.15	-1.81	.0505 (.007)	.6845 (.086)	.0238# (.059)			.4390 (.125)
6.23[1]	.987	692	1.14	-1.81	.0494 (.008)	.6871 (.079)		.0302# (.054)		.4306 (.125)
6.24[1]	.988	787	1.12	-1.98	.0452 (.007)	.7153 (.072)			.0627 (.028)	.3942 (.119)

Standard errors are presented in parentheses.
# indicates variable not significant at the 5 per cent level.
[1] Equations 6.22 to 6.24 are logarithmic transformations.

variables are elasticity estimates which measure the relative change in farmland values with respect to a given proportional change in the explanatory variable. The variables $DV1_{0-1}$ and X16 appear to have the greatest impact on the dependent variable while DECG1, although statistically significant, has considerably less impact. Generally, the statistical results for Equations 6.22 and 6.23 confirm the results of Equations 6.19 and 6.20. However, variable DX6 in this nonlinear formulation has an estimated coefficient that is significant at the 5 per cent level, implying a significant influence on the dependent variable (Equation 6.24). As well, the estimated elasticity coefficient for DX6 suggests that this variable might have the greatest impact on farmland values of all the expected productive return variables.

The statistical results in Table 6.3 provide valuable insight into the determination of real farmland values. The variables DER, $DX2_{0-1}$ and DX6 strongly suggest that expected productive returns have a direct influence on farmland values. As well, farm enlargement has a direct influence on farmland values and appears to be related to expected productive returns. The performance of variable $DV1_{0-1}$ implies that there is a partial adjustment process in the farmland market which results in the farmland values of previous years being an influence on current farmland values. Variable DECG1 is also a significant variable suggesting that previous gains in farmland values have an influence on current values. These observations are ultimately incorporated into the economic interpretations presented in Chapter Seven. However, a major statistical limitation to these results is the presence of autocorrelation. Models which do not include the lagged dependent variable have d-statistics which strongly indicate the presence of positive autocorrelation. This limits their value for economic interpretation since the coefficients may not be accurate estimates of the true parameters. The inclusion of variable $DV1_{0-1}$ appears to account for the systematic influence on the residual terms that is the source of autocorrelation. Therefore, variable $DV1_{0-1}$ provides an explanatory variable indicating the influence of past farmland values and its inclusion eliminates the source of serial correlation.[63]

Statistical results from the analysis of real provincial farmland values over the period from 1961 to 1980 are presented in Table 6.4 . These results tend to confirm the

[63] There are arguments that suggest the inclusion of a lagged dependent variable does not improve the economic capability of a model. See Griliches (1961, pp. 63–73).

Table 6.4:Estimates of Provincial Farmland Values Using Real Value Data, for the Period 1961 to 1980.

Equation	Adjusted R^2	F-statistic	d-statistic	Constant	DECG1	$DV1_{0-1}$	DER	$DX2_{0-1}$	DX6	X16
6.25	.379	12	.1079	97.19	2.16 (.624)					
6.26	.763	59	.594	11.46			.0940 (.010)			
6.27	.779	64	.598	15.88				.0874 (.010)		
6.28	.687	40	.650	36.61					1.645 (.260)	
6.29	.843	49	.306	21.7	1.078 (.349)		.0791 (.010)			
6.30	.794	36	.467	24.5	.6629# (.439)			.0762 (.010)		
6.31	.673	19	.532	40.9	.3304# (.642)				1.508 (.370)	
6.32	.958	209	1.51	6.96	1.304 (.171)	.9254 (.059)				
6.33	.862	39	.261	-23.6	1.350 (.359)		.0422 (.020)			.104 (.057)

Standard errors are presented in parentheses.
# indicates variable not significant at the 5 per cent level.

results derived for the period covering 1940 to 1980. The F−statistics and the adjusted R^2's for the models presented are comparable with those presented in Table 6.3 . Most of the estimated coefficients have increased standard errors which may reduce their statistical significance, however, this is most likely due to the reduced number of observations. The d−statistics suggest serial correlation among the error terms when the lagged dependent variable is not included as an explanatory variable. As was the case over the longer period, variable $DV1_{0-1}$ provides an economic explanation for the presence of serial correlation among the time−series data.

The relative influences of the explanatory variables on the dependent variable appear to be consistent with the longer time period. Variables DECG1, DER and $DX2_{0-1}$ each explains similar levels of the variation in the dependent variable as over the longer time period (Equation 6.25 to 6.27). The variable DX6, however, explains significantly more of the variation in real farmland values (Equation 6.28). This phenomenon might be explained by an increasing tendency toward cash rents which allow producers to compete for rented land. Therefore, farmland values and gross farm rent could be influenced by similar forces in the more recent period of observation. Furthermore, provincial gross farm rents are not adjusted for the amount of farmland rented, therefore variable DX6 is influenced by the amount of farmland being rented as well as the economic returns allocated to farmland by producers. If the amount of farmland rented in the period covering 1961 to 1980 was relatively stable while the amount rented during the period 1940 to 1980 was increasing, DX6 might be an improved measure of productive returns to farmland in the period covering 1961 to 1980. This feature could explain why the variable DX6 is able to explain a greater amount of the variation in farmland values over the more recent period.

The results of Equations 6.29 to 6.31 are reasonably consistent with those observed over the longer time period. Although the statistical significance of explanatory variables may be reduced the relationships among these variables are the same. Similarily, the estimates for Equàtions 6.32 to 6.38 given in Table 6.4 are consistent with those presented in Table 6.3. One exception is with the coefficient of variable $DX2_{0-1}$ which in Equation 6.37 has a changed sign. Multicollinearity resulting from the high level of correlation between variable $DX2_{0-1}$ and the variables X16 (.84) and $DV1_{0-1}$ (.83) has likely

Table 6.4(continued):Estimates of Provincial Farmland Values Using Real Value Data, for the Period 1961 to 1980.

Equation	Adjusted R^2	F-statistic	d-statistic	Constant	DECG1	$DV1_{0-1}$	DER	$DX2_{0-1}$	DX6	X16
6.34	.835	32	.294	-40.8	1.428 (.516)			.0197# (.030)		.1541 (.068)
6.35	.831	30	.293	-56.1	1.709 (.567)				.0066# (.460)	.1979 (.050)
6.36	.975	174	1.61	-28.9	1.470 (.155)	.8091 (.078)	-.0177# (.010)			.0829 (.025)
6.37	.979	217	1.71	-36.1	1.699 (.185)	.8035 (.078)		-.0261 (.010)		.1032 (.025)
6.38	.971	151	1.44	-18.67	1.327 (.243)	.7238 (.085)			.0293# (.190)	.0571 (.026)
6.39[1]	.953	92	1.84	-2.16	.0556 (.009)	.6792 (.121)	.0535# (.149)			.4813# (.241)
6.40[1]	.954	95	2.52	-1.90	.0518 (.011)	.6748 (.104)		.0956# (.247)		.4095# (.247)
6.41[1]	.969	142	2.25	-.903	.0429 (.009)	.7313 (.080)			.1518 (.055)	.2361# (.187)

Standard errors are presented in parentheses.
# indicates variable not significant at the 5 per cent level.
[1]Equations 6.39 to 6.41 are logarithmic transformations.

influenced the estimated coefficient in this case. Even though variable DX6 can explain a greater level of variation in farmland values in the period 1961 to 1980 than with the longer data series, the influence of this variable is suppressed when variables X16, DECG1 and $DV1_{0-1}$ are included in the same model (Equations 6.35 and 6.38). The results of the logarithmic transformations (Equations 6.39 to 6.41) suggest that the relative impact of explanatory variables are similar to those of the period 1940 to 1980. The relatively large elasticity estimates for the variables $DV1_{0-1}$ and X16 suggest that previous farmland values and farm enlargement have the greatest relative impact on farmland values. As well, the variable DX6 appears to have the greatest impact of the expected productive return variables on farmland values.

The single equation models presented in Table 6.3 and Table 6.4 do not suggest structural changes that would necessitate respecification of the models. The coefficients of the explanatory variables are generally reasonably stable over the differing periods of observation, so that the results of Table 6.4 do not suggest significant changes in the parameters of the farmland market. However, the coefficients of variable $DV1_{0-1}$ have increased slightly (Equations 6.36 and 6.37) which suggests that previous farmland values could have a greater influence on farmland values in the recent period of observation. The coefficients of adjustment derived from these equations are, therefore, slightly lower which implies the behavioral feature that previous farmland values are being considered over a greater number of past observations. The lowest coefficients of adjustment (Equations 6.36 and 6.37) occur when the expected productive return variables are DER and $DX2_{0-1}$ rather than DX6. Differing measures of economic returns in the expected productive return variables could lead to differing levels of dependence on previous farmland values in determining current farmland values.

Table 6.5 presents statistical results for estimates of real provincial farmland values over the period from 1961 to 1980. Variables representing economic development (X13), government credit programs (X17) and the relative influence of general price changes on agricultural product prices and on the cost of mortgage credit (X10/X11) which have not previously been considered in this study are included as explanatory variables. The data for these variables were not available over the longer time period from 1940 to 1980 .

Table 6.5:Estimates of Provincial Farmland Values Using Real Value Data, for the Period 1961 to 1980.

Equation	Adjusted R^2	F-statistic	d-statistic	Constant	DECG1	$DV1_{0-1}$	DER	DX6	X13	X17	X10/X11
6.42	.677	39	.485	52.6					9.49 (.015)		
6.43	.515	20	.445	70.9						.730 (.160)	
6.44	.653	35	.870	159.3							-.431 (.073)
6.45	.970	197	1.42	11.7	1.213 (.148)	.7651 (.078)			2.093 (.077)		
6.46	.977	196	1.97	18.1	1.298 (.134)	.9234 (.095)	-.0341 (.010)		4.150 (1.09)		
6.47	.942	99	1.40	-3.8	.4495 (.190)	.9324 (.084)				.2644 (.080)	
6.48	.939	71	1.38	-4.1	.3897# (.217)	.8887 (.112)		.1715 (.028)		.2210# (.110)	
6.49	.957	105	1.81	5.8	.9939 (.282)	.8102 (.128)	.0087# (.010)			.1089# (.090)	

Standard errors are presented in parentheses.
# indicates variable not significant at the 5 per cent level.

Each of these three variables is capable of explaining more than 50 per cent of the variation in the dependent variable (Equations 6.42 to 6.44). Variable X13 measures real gross domestic product per capita at the provincial level. This variable has tended to increase over time and is highly correlated with the variable DER (.93). Since agricultural production is a major component of Alberta's gross domestic product, the influence measured by variable DER is very likely also measured by variable X13. Variable X13 has a statistically significant influence on real farmland values when specified in the same model as DECG1 and $DV1_{0-1}$ (Equation 6.45). This model suggests that economic development, expected capital gains and previous farmland values all have an influence on farmland values. When variable DER is included as an explanatory variable (Equation 6.46), the coefficients of X13 change noticeably. Since variables DER and X13 are likely measuring similar influences, multicollinearity may explain the unexpected sign for DER.

Variable X17 provides a measure of concessional credit extended at the provincial level. This variable has high levels of correlation with variables DECG1 (.81) and DX6 (.85) . The high level of correlation between variables X17 and DECG1 could be explained by a cause and effect relationship between concessional credit and expected capital gains. Gross farm rents may be influenced by concessional credit if there are more entrants into the farming sector who would compete for rented land. When X17 is included in the same model as DECG1 and $DV1_{0-1}$ there is a noticeable reduction in the coefficient of DECG1 (Equations 6.47 and 6.48) perhaps due to these variables responding to similar influences. When variables DER and DX6 are included to represent the influence of expected productive returns, the significance of X17 is reduced. When variables DECG1, DX6 and X17 are specified in the same model (Equation 6.48), DX6 appears to account for the effect of concessional credit and expected capital gains as an influence on real farmland values. In Equation 6.49, neither of variables X17 or DER are statistically significant perhaps since DECG1 accounts for the influence of concessional credit and $DV1_{0-1}$ accounts for some portion of the expected productive returns influence. With the logarithmic specifications given in Equations 6.52 and 6.53, variables X17 and DECG1 are each able to account for significant influences on farmland values. The logarithmic transformation of data has reduced the level of correlation between these variables to .51 from .81 which thus might explain concessional credit and

expected capital gains both having an influence on farmland values. As well, the correlation between DX6 and DECG1 is reduced from .71 to .41 in the logarithmic transformation. Accordingly, gross farm rent and expected capital gains both have an influence on farmland values in Equation 6.55.

Variable X10/X11 appears to have a significant inverse influence on farmland values (Equations 6.50 and 6.51). The inverse influence likely arises since mortgage credit costs are increasing at a greater rate than are agricultural product prices and thus may be imposing a cost-price squeeze on farmland values.[64] Variable X10/X11 is highly correlated with the variables $DV1_{0-1}$ (-.91) and DER (-.88). $DV1_{0-1}$ measures the influence of previous farmland values and the variable X10/X11 tends to decline in value as the lagged dependent variable increases in value. Therefore, the reduced coefficients of $DV1_{0-1}$ in these models suggests that a portion of the lagged response measured by this variable is accounted for by the of X10/X11. Similarily, any "cost-price squeeze" would be reflected in expected productive returns which would explain the reduced significance of DER in Equation 6.50.

One of the hypotheses presented in Chapter Four suggests that general price changes could have differing effects on output prices, input prices and discount rates. Consequently, the effects of inflation on farmland values would not have a predictable direction. However, the argument was made that institutional factors such as concessional credit, fixed interest rates and unanticipated inflation might have allowed productive returns to increase at a greater rate than discount rates. As a result, the combined influence of inflation and these institutional factors are anticipated to positively influence farmland values. The variable X10/X11 is constructed to test whether there is an indication of effects on farmland values from inflation-related differences between growth in productive returns to farmland and on discount rates. The variable X10/X11, however, does not appear to reflect the influence of the institutional factors described. The cost of mortgage credit has increased at a rate faster than have the prices of agricultural products. This result might be explained by the feature that the mortgage credit index uses increasing values of farmland and buildings as a component of the index. Variable X10/X11 does not appear to measure the intended influence and thus is

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[64] When observed over time the variable X10/X11 generally declines in value.

Table 6.5(continued):Estimates of Provincial Farmland Values Using Real Value Data, for the Period 1961 to 1980.

Equation	Adjusted R^2	F-statistic	d-statistic	Constant	DECG1	$DV1_{0-1}$	DER	DX6	X13	X17	X10/X11
6.50	.978	204	1.47	85.7	1.634 (.162)	.5728 (.114)	-.016# (.010)				-.231 (.059)
6.51	.976	186	1.20	59.8	1.349 (.209)	.5390 (.116)		.1338# (.140)			-.1605 (.053)
6.52[1]	.965	126	2.14	-.548	.0341 (.009)	.7558 (.104)	.1270# (.105)			.0752 (.023)	
6.53[1]	.970	148	2.51	-.701	.0336 (.008)	.8144 (.053)		.1258# (.063)		.0434# (.029)	
6.54[1]	.968	138	2.13	.710	.0411 (.008)	.7486 (.075)		.1395# (.066)	.0659# (.059)		
6.55[1]	.965	127	2.25	.262	.0376 (.008)	.7963 (.106)		.1905 (.008)			-.006# (.058)

Standard errors are presented in parentheses.
# indicates variable not significant at the 5 per cent level.
[1]Equations 6.52 to 6.55 are logarithmic transformations.

not consistent with the anticipated influence that inflation combined with the institutional factors described might have on farmland values.

The statistical results given in Table 6.5 suggest that each of the newly introduced explanatory variables has an influence on real farmland values. The coefficient estimates for variable X13 are consistent with the hypothesis that economic development or general population pressures have an influence on Alberta farmland values. As well, the relationship of variable X17 to farmland values is consistent with the hypothesized influence of concessional credit on Alberta farmland values. The estimated coefficients for variable X10/X11 suggest that inflation has varying effects on output prices and input prices which exerts an influence on farmland values. However, this variable does not appear to capture the influence of institutional factors which might cause private discount rates to remain relatively low (with respect to general price increases). The observed relationship between variables X17 and DECG1 suggests that the use of concessional credit is related to expectations of real capital gains or vice versa. Consequently, this particular relationship deserves consideration in future studies.

Many of the explanatory variables observed over time may show similar variations as a result of the influence of economic cycles. Therefore, these variables may have contemporaneous relationships as suggested by their high correlations. As well, some of the explanatory variables, rather than being independent, may have cause and effect relationships such that two variables may be measuring a similar economic influence.[65] Unfortunately, these relationships present statistical limitations to economic inferences. A model incorporating most of the economic relationships which function to determine provincial farmland values is not likely to be achieved since multicollinearity and autocorrelation restrict the number of explanatory variables which can statistically be included in a model. As a result, the models presented have the characteristics of reduced form models which describe relationships among variables representing economic forces. The economic content of these models may be limited since many of the direct economic influences on farmland values suggested by economic theory are not included. High correlations among explanatory variables are also likely due to the use of highly aggregated data. As a result, the number of specific economic forces which can

[65] One example is the probable relationship that farm enlargement (represented by X16) may have with the variables representing expected productive returns.

be included in a model are reduced. As well, most of the variables which are included in the models represent demand-related forces. Data on the quantity of farmland supplied are not available for inclusion in these time-series models which prevents the specification of a model which might reveal further influences on farmland values.

The analysis of farmland values at the census division level requires the pooling of data over census divisions as well as over time. The primary reason for pooling is to obtain a sufficient number of observations of the quantity of farmland transferred to allow a statistical analysis of this force without the complication of too few degrees of freedom. Incorporating the quantity of farmland transferred into a recursive model may allow a more appealing explanation of the farmland market since the interrelated nature of explanatory variables can be specified. In this case predetermined variables (of quantity transferred) are included as explanatory variables influencing farmland values. A further benefit of using pooled data may also be in reducing the incidence of multicollinearity and autocorrelation. These statistical complications are the result of strong trends in time-series data that have tended to dominate explanatory variables observed over time. The inclusion of cross-sectional observations, therefore, may reduce the influence of similar trends over time.

C. Census Division Analysis

The analysis of farmland values at the census division level incorporates the recursive model 5.2 presented in Chapter Five and uses pooled time-series and cross-sectional data. The data are observed over the 15 census divisions in Alberta and over the years from 1971 to 1980 .[66] The dependent variables measuring the quantity of farmland transferred (T2) and agricultural real estate values (DV2) are subject to influences which vary over census divisions and over time. In the previous analysis of real farmland values, the dependent variable was estimated over time while the geographical unit of the province (essentially a cross-sectional unit) remained constant. Census division

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[66] Data measuring farmland values and the quantity of farmland transferred are available at the census division level for the period 1971 to 1980 . However, the construction of lagged variables reduces the number of observations which may be included in a specification. Variable DECG2 is a fully distributed lag of previous real gains in farmland values observed over two years. As a result, the number of observations of DECG2 is reduced to cover 1973 to 1980. As well, income data at the census division level is available only over the period covering 1972 to 1976. When these variables are lagged one year the number of observations is reduced, and covers the period 1973 to 1976.

farmland values and quantities of farmland transferred are estimated by explanatory variables that measure the hypothesized influences as well as dummy variables which measure the influence of variations over census divisions and over time.

The statistical results presented are for models which estimate the quantities of farmland transferred (Table 6.6) and farmland values (Table 6.7) at the census division level. The format for presenting these empirical results is changed to accomodate the many dummy variables representing census divisions and years. The variables are presented in the first column, their estimated coefficients in the second column, their standard errors in the third column and the t-statistic calculated to test the statistical significance of each variable is in column four. As before, estimated coefficients which are not significant at the 5 per cent level of significance are denoted by # . The results indicate the quantitative influence of the explanatory variables and the qualitative influence of the dummy variables. The coefficients of the dummy variables measure the deviations between the mean intercept (the constant term) and the intercept for the specific year or census division.

Table 6.6 presents equations estimating quantities of farmland transferred at the census division level. The time period over which these estimates are derived are given in parentheses below the equation number. The number of years observed is also indicated by the number of dummy variables included to represent years. One dummy variable is excluded from those representing years and from those representing census divisions since the excluded dummy variable is determined by the remaining dummies (measuring the same qualitative influence) in the specification.[67] In Equation 6.56, dummy variables CD1 to CD14 have estimated coefficients which measure the difference between the constant intercept term and the intercept for the particular census division. As well, dummy variables YR73 to YR79 have coefficients which measure the difference between the constant term and the intercept specific to each year. The constant term is the intercept for Census Division 15 and year 1980. The intercept for Census Division 15 and year 1978 is the constant term plus the coefficient of YR78 which is 308441.0 + 42919.0 = 351360.0 . The intercept for Census Division 14 in year 1973 is 308441.0 −

[67] The Kth dummy variable can be determined by the K−1 dummies included in an equation due to the 1 or 0 values which indicate presence or absence of the qualitative influence of census divisions or years. When the K−1 dummies are all absent, the combination of all 0's represents the Kth dummy variable.

Table 6.6:Estimates of Quantities of Farmland Transferred at the Census Division Level.

Equation	Variable	Coefficient	Standard Error	t-statistic
6.56	CD1	-233594	20406	-11.45
(73-80)	CD2	-248012	19158	-12.95
	CD3	-224219	21510	-10.42
	CD4	-244901	21663	-11.31
	CD5	-199877	17736	-11.27
	CD6	-222032	20323	-10.93
	CD7	-154910	17409	-8.90
	CD8	-218614	17636	-12.4
	CD9	-328426	25657	-12.8
	CD10	-106626	17573	-6.07
	CD11	-214674	18364	-11.69
	CD12	-234973	22018	-10.67
	CD13	-171720	17462	-9.83
	CD14	-299513	25009	-11.98
	DECG2	-249.88	242.33	-1.03#
	X27	.0128	.0027	4.74
	YR73	28086	13198	2.13
	YR74	34205	12739	2.68
	YR75	26141	12808	2.04
	YR76	62162	15691	3.96
	YR77	30590	13893	2.20
	YR78	42929	14117	3.64
	YR79	21751	12831	1.69
	(Const.)	308441		

Adjusted R^2: .898
F-statistic: 47
# indicates variable not significant at the 5 per cent level.

Table 6.6(continued):Estimates of Quantities of Farmland Transferred at the Census Division Level.

Equation	Variable	Coefficient	Standard Error	t-statistic
6.57	CD1	-236022	20939	-11.27
(73-80)	CD2	-254581	22561	-11.28
	CD3	-230361	24246	-9.5
	CD4	-244512	21752	-11.24
	CD5	-206157	21075	-9.78
	CD6	-236196	32617	-7.24
	CD7	-156472	17696	-8.84
	CD8	-227239	23527	-9.66
	CD9	-339860	32443	-10.32
	CD10	-110130	18728	-5.88
	CD11	-223608	24443	-9.15
	CD12	-236243	22214	-10.63
	CD13	-174077	18029	-9.66
	CD14	-301524	25358	-11.89
	X27	.0127	.0027	4.68
	$DV1_{t-1}$	87.07	156.5	.556#
	DECG2	-207	255	-.812#
	YR73	37335	21252	1.75
	YR74	43616	21199	2.06
	YR75	33682	18678	1.80
	YR76	67462	18404	3.66
	YR77	34381	15519	2.22
	YR78	44875	14597	3.07
	YR79	23267	13162	1.78
	(Const.)	297828		

Adjusted R^2: .897
F-statistic: 44
# indicates variable not significant at the 5 per cent level.

Table 6.6(continued):Estimates of Quantities of Farmland Transferred at the Census Division Level.

Equation	Variable	Coefficient	Standard Error	t-statistic
6.58	CD1	-253997	19849	-12.80
(73-80)	CD2	-222329	20142	-11.04
	CD3	-244100	20860	-11.70
	CD4	-273937	20564	-13.32
	CD5	-198769	19071	-10.42
	CD6	-225042	22810	-9.87
	CD7	-150357	18249	-8.24
	CD8	-207430	19775	-10.49
	CD9	-354208	24559	-14.46
	CD10	-97295	18563	-5.24
	CD11	-214542	20058	-10.70
	CD12	-263345	20697	-12.72
	CD13	-172400	18316	-9.41
	CD14	-336767	22452	-14.99
	DECG2	-170.7	228.16	-.748#
	X27	.0070	.0020	3.51
	$DV1_{0-1}$	-119	76.55	-1.55#
	(Const.)	388044		

Adjusted R^2: .889
F-statistic: 57
# indicates variable not significant at the 5 per cent level.

Table 6.6(continued):Estimates of Quantities of Farmland Transferred at the Census Division Level.

Equation	Variable	Coefficient	Standard Error	t-statistic
6.59	CD1	-130911	55165	-2.37
(73-76)	CD2	-90399	92879	-.973#
	CD3	-107579	74683	-1.44#
	CD4	-157444	43520	-3.62
	CD5	-103496	48850	-2.12
	CD6	-182613	32757	-5.57
	CD7	-91679	33557	-2.73
	CD8	-172283	28315	-6.08
	CD9	-290987	34928	-8.33
	CD10	-37202	28665	-.290#
	CD11	-212636	27441	-7.75
	CD12	-205847	29800	-6.91
	CD13	-137387	27051	-5.08
	CD14	-267852	33823	-7.92
	DECG2	-153.9	317.96	-.485#
	X27	.0157	.0043	3.61
	$DX21_{0-1}$	-1.62	1.38	-1.17#
	YR73	-49956	21217	-2.35
	YR74	-35955	19439	-1.84
	YR75	-48252	21265	-2.27
	(Const.)	347877		

Adjusted R^2: .883
F-statistic: 23
# indicates variable not significant at the 5 per cent level.

Table 6.6(continued):Estimates of Quantities of Farmland Transferred at the Census Division Level.

Equation	Variable	Coefficient	Standard Error	t-statistic
6.60	CD1	-169885	35545	-4.78
(73-76)	CD2	-177519	38046	-4.66
	CD3	-180305	31086	-5.80
	CD4	-180022	35534	-5.07
	CD5	-127797	40815	-3.13
	CD6	-173440	47032	-3.69
	CD7	-101888	31815	-3.20
	CD8	-177595	27964	-6.35
	CD9	-278430	37317	-7.46
	CD10	-38787	28928	-1.34#
	CD11	-193108	36081	-5.35
	CD12	-214460	31801	-6.74
	CD13	-140158	27763	-5.05
	CD14	-268729	34642	-7.76
	DECG2	-228.3	334.2	-.683#
	X27	.0143	.0043	3.30
	$DX23_{0-1}$	-5.27	6.82	-.774#
	YR73	-54348	29022	-1.87
	YR74	-41451	22441	-1.84
	YR75	-42915	21015	-2.04
	(Const.)	364261		

Adjusted R^2: .880
F-statistic: 23
# indicates variable not significant at the 5 per cent level.

Table 6.6(continued):Estimates of Quantities of Farmland Transferred at the Census Division Level.

Equation	Variable	Coefficient	Standard Error	t-statistic
6.61	CD1	-187087	27592	-6.78
(73-76)	CD2	-192634	32482	-5.93
	CD3	-188389	29135	-6.47
	CD4	-195042	29612	-6.59
	CD5	-151281	27147	-5.57
	CD6	-202493	28174	-7.19
	CD7	-111549	29116	-3.83
	CD8	-180390	27589	-6.54
	CD9	-288060	35003	-8.23
	CD10	-41608	28553	-1.45#
	CD11	-211018	27536	-7.66
	CD12	-206492	29936	-6.89
	CD13	-136246	27161	-5.02
	CD14	-263335	33763	-7.80
	DECG2	-156.5	319.5	-.489#
	X27	.0149	.0043	3.43
	YR73	-36881	18145	-2.03
	YR74	-43109	20907	-2.66
	YR75	-32775	19341	-1.69
	(Const.)	327546		

Adjusted R^2: .882
F-statistic: 24
# indicates variable not significant at the 5 per cent level.

299513.0 + 28086.0 = 37014.0 . The negative coefficient values for CD1 to CD14 indicate that all census divisions have less quantities of farmland transferred than Census Division 15. The geographic descriptions of the census divisions in Alberta can be observed in Figure 6.1 . This map indicates that Census Division 15 covers the largest geographic area which accounts for it having the largest amount of farmland transferred. The dummy variables YR73 to YR79 all have positive coefficients suggesting that quantities of farmland transferred were greater in the years prior to 1980 . DECG2 and X27 are explanatory variables representing the influence of expected real capital gains and concessional credit. Variable X27 has a statistically significant influence on the quantities of farmland transferred and variable DECG2 does not.

Equation 6.57 includes variable $DV2_{0-1}$, the previous year's farmland values. This explanatory variable is included since the quantity of farmland transferred in the current year may be a function of farmland values in the previous year. Variable $DV2_{0-1}$ is not statistically significant with respect to the quantities of farmland transferred. However, the inclusion of this variable appears to have added a dynamic element to the model which reduces the significance of the dummy variables YR73 to YR76 . The inclusion of $DV2_{0-1}$ does not change the dummy variables CD1 to CD14 . The estimated coefficient for variable X27 is reasonably stable over the models which could suggest that some confidence may be placed on the inclusion of this variable.

Equation 6.58 does not include the dummy variables YR73 to YR79 . Some of the variations which occur over time may be measured by the variable $DV2_{0-1}$. However, this variable does not have a statistically significant influence on the dependent variable. This model specification, by not including the dummy variables YR73 to YR79, restricts the influence of time-series variation on farmland values. Therefore, all variations in the quantities of farmland transferred are due to variations over census divisions and the influence of concessional credit. As well, the estimated coefficient of X27 is noticeably decreased causing this variable to have slightly decreased significance. Since this model does not account for the influence of time-series variation on the quantities of farmland transferred, it is a less desirable specification than those of Equations 6.56 and 6.57 .

Equations 6.59 to 6.61 estimate the quantities of farmland transferred over the period from 1973 to 1976 . These equations allow for the inclusion of the variables

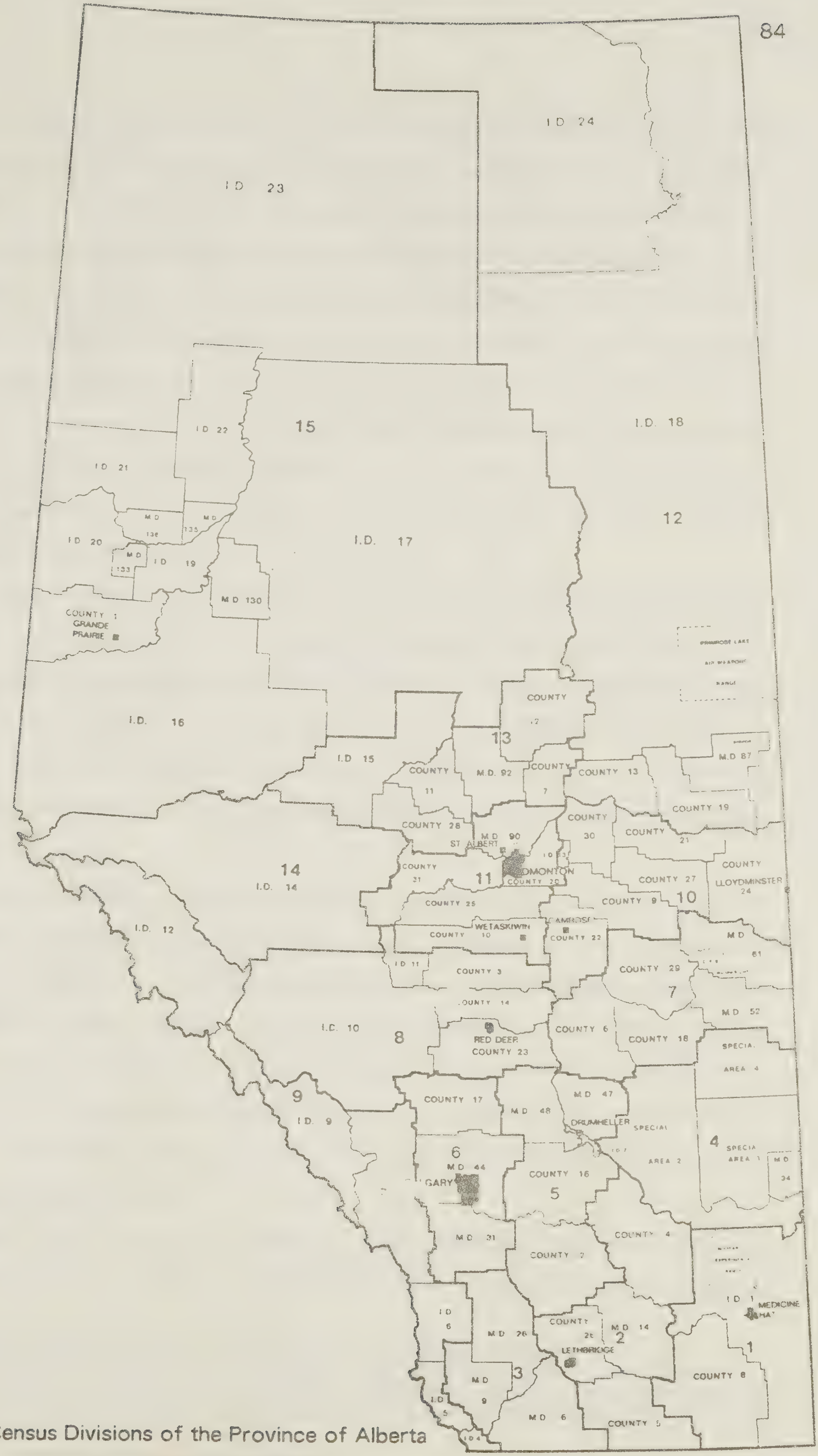

Figure VI.1 Census Divisions of the Province of Alberta

DX21 (average gross farm income per farm taxfiler per census division) and DX23 (total net income per farm taxfiler per census division). The coefficients for the explanatory variables $DX21_{0-1}$ and $DX23_{0-1}$ are not statistically significant and do not contribute to an improved explanation of the quantities of farmland transferred. Over the shorter period of observations, the variable X27 remains statistically significant. As well, the estimated coefficient for variable X27 is slightly larger (than in Equations 6.56 to 6.58) which could suggest a greater response to concessional credit in quantity of farmland transferred over the time period covering 1973 to 1976. Dummy variable CD10 is not statistically significant in any of these models. However, this result would only imply that the quantity of farmland transferred in Census Division 10 is not significantly different from that transferred in Census Division 15 .

In all of the models estimating quantities of farmland transferred, the explanatory variable X27 is statistically significant. There is also general consistency of the dummy variables representing variations among census divisions and years. The statistical criteria (Adjusted R^2 and F-statistic) for these models are all at adequate levels regarding explanatory power and reliability.[68] The estimated quantities of farmland transferred derived from these models are then used as explanatory variables in estimating census division farmland values.

Table 6.7 presents the statistical results for equations estimating census division farmland values. Explanatory variables used in these estimates include predetermined variables for quantities of farmland transferred (PT2), expected real capital gains variables (DECG2) and, in specific cases, variables representing expected productive returns to farmland and off-farm sources of returns. Equations 6.62 to 6.67 cover the period from 1973 to 1980 while Equations 6.68 to 6.71 cover the period from 1973 to 1976 . The reduced time period allows inclusion of variables for which data were not available over the longer period.

Equation 6.62 includes the variable T2 which measures observed (rather than predicted) quantities of farmland transferred. This variable is included primarily to provide

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[68] The Durbin-Watson d-statistic is not relevant in the overall regression of cross-sectional and time-series data. Logically, cross-sectional units are not serially correlated; therefore, changes in the ordering in which cross-sectional units are included in the overall regression cause the d-statistic to have differing values while the parameter estimates would be unchanged.

Table 6.7:Estimates of Census Division Farmland Values Using Real Value Data.

Equation	Variable	Coefficient	Standard Error	t-statistic
6.62	CD1	26.61	16.36	1.63#
(73-80)	CD2	78.04	13.62	5.73
	CD3	67.57	16.37	4.12
	CD4	-5.55	17.25	-.321#
	CD5	72.16	13.74	5.25
	CD6	154.52	15.86	9.74
	CD7	20.02	11.55	1.73
	CD8	98.02	13.92	7.04
	CD9	123.67	21.98	5.63
	CD10	40.25	10.19	3.94
	CD11	98.16	14.68	6.68
	CD12	11.89	16.96	.701#
	CD13	27.34	12.50	2.19
	CD14	19.22	20.55	.935#
	DECG2	.9036	.1255	7.20
	T2	.0148	.050	.310#
	YR73	-107.68	6.82	-15.79
	YR74	-97.71	6.80	-14.37
	YR75	-85.14	6.82	-12.48
	YR76	-66.34	6.71	-9.89
	YR77	-44.10	6.72	-6.57
	YR78	-28.99	6.65	-4.36
	YR79	-12.12	6.64	-1.82
	(Const.)	120.23		

Adjusted R^2: .927
F-statistic: 66
# indicates variable not significant at the 5 per cent level.

Table 6.7(continued):Estimates of Census Division Farmland Values Using Real Value Data.

Equation	Variable	Coefficient	Standard Error	t-statistic
6.63	CD1	11.44	32.51	.352#
(73-80)	CD2	66.79	24.89	2.68
	CD3	52.42	32.48	1.61#
	CD4	-21.89	34.83	-.628#
	CD5	60.70	25.29	2.40
	CD6	140.30	30.69	4.57
	CD7	12.05	18.75	.643#
	CD8	86.39	25.65	3.37
	CD9	101.38	46.77	2.17
	CD10	35.13	13.92	2.52
	CD11	85.43	27.78	3.08
	CD12	-4.06	34.06	-.118#
	CD13	17.76	21.71	.819#
	CD14	-1.30	43.21	-.032#
	DECG2	.8980	.1259	7.13
	$PT2_1$	.0385	.011	.351#
	YR73	-106.75	7.04	-15.17
	YR74	-96.07	7.45	-12.90
	YR75	-83.55	7.43	-11.25
	YR76	-65.34	6.95	-9.40
	YR77	-43.80	6.74	-6.50
	YR78	-28.27	6.78	-4.17
	YR79	-11.45	6.76	-1.69
	(Const.)	142.22		

Adjusted R^2: .927
F-statistic: 66
# indicates variable not significant at the 5 per cent level.

Table 6.7(continued):Estimates of Census Division Farmland Values Using Real Value Data.

Equation	Variable	Coefficient	Standard Error	t-statistic
6.64	CD1	46.07	32.27	143#
(73-80)	CD2	92.47	24.71	3.74
	CD3	87.00	32.24	2.70
	CD4	15.41	34.57	.446#
	CD5	86.86	25.11	3.46
	CD6	172.81	30.58	5.65
	CD7	30.25	18.62	.1.62#
	CD8	112.94	25.47	4.43
	CD9	152.26	46.41	3.28
	CD10	46.81	13.84	3.38
	CD11	114.49	27.58	4.15
	CD12	32.35	33.81	.957#
	CD13	39.63	21.56	1.83
	CD14	45.54	42.88	.1.06#
	DECG2	.9106	.1256	7.25
	$PT2_2$	.0832	.110	.764#
	YR73	-108.83	7.00	-15.54
	YR74	-99.82	7.42	-13.45
	YR75	-87.18	7.40	-11.78
	YR76	-67.62	6.93	-9.75
	YR77	-44.49	6.72	-6.62
	YR78	-29.92	6.76	-4.42
	YR79	-12.97	6.74	-1.84
	(Const.)	92.02		

Adjusted R^2: .927
F-statistic: 66
# indicates variable not significant at the 5 per cent level.

Table 6.7(continued):Estimates of Census Division Farmland Values Using Real Value Data.

Equation	Variable	Coefficient	Standard Error	t-statistic
6.65	CD1	21.28	10.65	1.99
(73-80)	CD2	75.74	9.99	7.58
	CD3	62.05	11.22	5.53
	CD4	-11.44	11.30	-1.01#
	CD5	68.65	9.25	7.42
	CD6	149.56	10.60	14.10
	CD7	17.93	9.08	1.97
	CD8	94.80	9.20	10.30
	CD9	115.51	13.39	8.63
	CD10	39.06	9.17	4.26
	CD11	94.09	9.58	9.82
	CD12	6.04	11.49	.526#
	CD13	24.51	9.11	2.69
	CD14	11.64	13.05	.892#
	DECG2	.9053	.1264	7.16
	X27	-.0000	.000	-.200#
	YR73	-107.67	6.89	-15.64
	YR74	-97.33	6.65	-14.64
	YR75	-84.62	6.68	-12.66
	YR76	-67.02	8.19	-7.58
	YR77	-44.57	7.25	-6.15
	YR78	-29.44	7.37	-3.99
	YR79	-12.13	6.69	-1.81
	(Const.)	128.63		

Adjusted R^2: .927
F-statistic: 66
# indicates variable not significant at the 5 per cent level.

Table 6.7(continued):Estimates of Census Division Farmland Values Using Real Value Data.

Equation	Variable	Coefficient	Standard Error	t-statistic
6.66	CD1	-16.88	18.19	-.928#
(73-80)	CD2	4.24	14.77	.288#
	CD3	-4.17	18.70	-.224#
	CD4	-28.65	19.18	-1.49#
	CD5	3.38	14.85	.228#
	CD6	21.24	19.58	1.06#
	CD7	-7.00	10.51	-.666#
	CD8	9.78	15.57	.628#
	CD9	-.403	27.41	.000#
	CD10	3.04	8.13	.374#
	CD11	6.98	16.74	.417#
	CD12	-23.23	18.90	-1.23#
	CD13	-7.98	12.24	-.652#
	CD14	-28.72	24.03	-1.19#
	DECG2	1.22	.072	16.94
	$DV1_{0-1}$	.6760	.045	14.28
	PT_2	-.0826	.060	-1.36#
	YR73	-33.55	6.32	-5.30
	YR74	-21.44	6.23	-3.24
	YR75	-23.92	5.86	-4.08
	YR76	-20.73	4.92	-4.21
	YR77	-12.60	4.26	-2.96
	YR78	-10.71	3.92	-2.73
	YR79	1.44	3.82	.375#
	(Const.)	71.72		

Adjusted R^2: .978
F-statistic: 222
# indicates variable not significant at the 5 per cent level.

Table 6.7(continued):Estimates of Census Division Farmland Values Using Real Value Data.

Equation	Variable	Coefficient	Standard Error	t-statistic
6.67	CD1	-121.93	54.85	-2.22
(73-80)	CD2	-32.42	41.22	-.786#
	CD3	-80.97	54.85	-1.48#
	CD4	-165.43	58.93	-2.81#
	CD5	-40.31	41.93	-.961#
	CD6	14.24	51.93	.274#
	CD7	-58.09	29.79	-1.95
	CD8	-16.31	42.62	-.383#
	CD9	-94.43	79.98	-1.18#
	CD10	-10.09	20.34	-.496#
	CD11	-26.96	46.47	-.581#
	CD12	-144.40	57.64	-2.51
	CD13	-66.58	35.34	-1.88
	CD14	-181.84	73.81	-2.46
	DECG2	.8848	.1212	7.30
	$PT2_3$	-.5074	.190	-2.76
	YR73	-104.02	6.66	-15.61
	YR74	-91.61	6.75	-13.58
	YR75	-78.45	6.85	-11.45
	YR76	-74.14	7.09	-10.45
	YR77	-48.12	6.66	-7.23
	YR78	-35.39	6.85	-5.17
	YR79	13.37	6.41	-2.09
	(Const.)	343.98		

Adjusted R^2: .932
F-statistic: 71
# indicates variable not significant at the 5 per cent level.

Table 6.7(continued):Estimates of Census Division Farmland Values Using Real Value Data.

Equation	Variable	Coefficient	Standard Error	t-statistic
6.68	CD1	45.28	25.84	1.75
(73-76)	CD2	69.79	16.81	4.15
	CD3	87.14	27.23	3.20
	CD4	24.44	28.77	.849#
	CD5	64.59	18.50	3.49
	CD6	130.08	28.47	4.57
	CD7	18.45	10.99	1.67#
	CD8	91.82	19.65	4.67
	CD9	137.76	42.72	3.22
	CD10	23.29	6.97	3.34
	CD11	79.89	24.94	3.20
	CD12	47.31	30.10	1.57#
	CD13	35.55	15.27	2.39
	CD14	63.03	39.14	1.61#
	DECG2	.9612	.0857	11.20
	$PT2_4$	.1745	.110	1.51#
	$DX23_{0-1}$	.0028	.0017	1.63#
	YR73	-33.38	7.32	-4.56
	YR74	-28.85	5.29	-5.45
	YR75	-22.79	4.78	-4.77
	(Const.)	-5.56		

Adjusted R^2: .956
F-statistic: 65
# indicates variable not significant at the 5 per cent level.

Table 6.7(continued):Estimates of Census Division Farmland Values Using Real Value Data.

Equation	Variable	Coefficient	Standard Error	t-statistic
6.69	CD1	9.36	9.27	1.01#
(73-76)	CD2	47.02	8.34	5.64
	CD3	47.48	7.68	6.18
	CD4	-16.69	8.89	-1.88
	CD5	39.54	10.62	3.72
	CD6	89.49	12.40	7.22
	CD7	6.10	7.57	.805#
	CD8	63.72	7.13	8.93
	CD9	74.52	8.06	9.24
	CD10	22.85	7.09	3.22
	CD11	45.43	9.39	4.84
	CD12	3.00	7.36	.409#
	CD13	16.90	7.23	2.34
	CD14	4.30	7.10	.606#
	DECG2	.9833	.0904	10.88
	$PT2_5$	.0000	.000	.970#
	$DX23_{0-1}$	.0029	.0018	1.63#
	YR73	-30.49	7.37	-4.14
	YR74	-24.95	5.06	-4.93
	YR75	-17.88	3.64	-4.91
	(Const.)	54.40		

Adjusted R^2: .955
F-statistic: 63
# indicates variable not significant at the 5 per cent level.

Table 6.7(continued):Estimates of Census Division Farmland Values Using Real Value Data.

Equation	Variable	Coefficient	Standard Error	t-statistic
6.70	CD1	21.97	9.54	2.30
(73-76)	CD2	57.69	9.95	5.30
	CD3	55.35	9.38	5.96
	CD4	-4.98	9.43	-.528#
	CD5	55.23	9.44	5.85
	CD6	104.84	7.80	13.44
	CD7	13.20	8.81	1.50#
	CD8	65.83	7.53	8.74
	CD9	73.75	16.57	4.45
	CD10	24.89	7.64	3.26
	CD11	49.70	13.39	3.71
	CD12	-1.47	7.42	-.200#
	CD13	14.31	7.27	1.97
	CD14	-3.60	14.53	-.247
	DECG2	.9700	.1099	8.82
	$PT2_5$	.0000	.000	.611#
	DX22/DX21	12.69	26.42	.481#
	YR73	-38.95	5.45	-7.15
	YR74	-29.69	4.21	-7.05
	YR75	-18.20	3.82	-4.76
	(Const.)	69.96		

Adjusted R^2: .952
F-statistic: 59
# indicates variable not significant at the 5 per cent level.

Table 6.7(continued):Estimates of Census Division Farmland Values Using Real Value Data.

Equation	Variable	Coefficient	Standard Error	t-statistic
6.71	CD1	17.30	7.47	2.32
(73-76)	CD2	56.09	8.79	6.38
	CD3	51.22	7.89	6.49
	CD4	-9.79	8.02	-1.22#
	CD5	53.74	7.35	7.31
	CD6	105.94	7.63	13.89
	CD7	11.66	7.88	1.48#
	CD8	65.62	7.47	8.78
	CD9	78.23	9.48	40.17
	CD10	24.00	7.73	3.10
	CD11	54.17	7.46	7.27
	CD12	-1.76	8.11	-.217#
	CD13	14.12	7.35	1.92
	CD14	.9441	9.14	.105
	DECG2	.9242	.0865	10.69
	X27	.0003	.000	.316#
	YR73	-40.14	4.91	-7.15
	YR74	-29.88	5.24	-5.71
	YR75	-17.31	5.66	-3.06
	(Const.)	77.99		

Adjusted R^2: .952
F-statistic: 63
# indicates variable not significant at the 5 per cent level.

a basis of comparison for the other estimates of quantities transferred. Variable T2 does not have a statistically important influence on census division farmland values and thus contributes very little to the model. DECG2 is statistically significant which suggests that expected real capital gains are an important influence on farmland values at the census division level. The dummy variables YR73 to YR79 have negative coefficients which would indicate that census division farmland values have been increasing each year. The dummy variables CD1 to CD14, with the exception of CD4, have positive coefficients. These results would indicate that farmland values are generally greater in all census divisions (except Census Division 4) than they are in Census Division 15 . Furthermore, the largest coefficient estimates are for Census Divisions 6, 9, 8 and 11 . These particular census divisions have characteristics which would explain the larger coefficients. These include proximity to major cities (CD11 and CD6), location in the black soil zone (CD11 and CD8) and high recreational value (CD9).

Equation 6.63 includes predicted quantities of farmland transferred ($PT2_1$) as an explanatory variable. $PT2_1$ is derived from Equation 6.56 . Even though $PT2_1$ is not a statistically significant influence on the dependent variable, it may account for some cross-sectional influences. Dummy variables CD1 to CD14 all have reduced significance when $PT2_1$ is included in the model (in comparison with Equation 6.62). The coefficients of the dummy variables YR73 to YR79 are very similar to those in the previous model. As well, variable DECG2 remains statistically significant and has a coefficient similar to that in Equation 6.62 .

Equation 6.64 includes the predetermined variable $PT2_2$ derived from Equation 6.57 . This variable does not have a statistical influence on census division farmland values and appears to have less of a cross-sectional influence than $PT2_1$. The statistical significance of the dummy variables CD1 to CD14 have increased slightly in this model. The dummy variables CD6, CD8, CD9 and CD11 continue to have larger coefficients. Variable DECG2 is statistically significant and has an estimated coefficient consistent with previous specifications.

Equation 6.65 does not include a variable which estimates the quantity of farmland transferred. Instead, variable X27 is included as an explanatory variable since the predetermined transfer variable is not statistically significant. Variable X27 does not

seem to have a significant influence on farmland values and does not appear to account for cross-sectional influences in the model. The estimates for the dummy variables CD1 to CD14 have reduced standard errors and greater significance levels. However, the statistical results for these dummy variables as well as dummies YR73 to YR79 and variable DECG2 are very similar to previous results.

Equation 6.66 includes the lagged dependent variable $DV2_{0-1}$ as well as $PT2_2$. Variable $DV2_{0-1}$ has a dominating influence and it accounts for most of the cross-sectional influence in the model. The dummy variables estimated for CD1 to CD14 are no longer statistically significant and the coefficients for the dummy variables YR73 to YR79 are all reduced. The two variables, DECG2 and $DV2_{0-1}$, tend to account for nearly all cross-sectional and time-series changes. These results are very similar to those obtained in the earlier time-series analysis of provincial farmland values.

Equation 6.67 includes as an explanator the predetermined variable of $PT2_3$. This variable is derived from Equation 6.58 which assumes that variations over time are not significant with respect to the quantities of farmland transferred. Since variable $PT2_3$ is largely determined by cross-sectional influences, it accounts for a large amount of cross-sectional influence in Equation 6.67 . Furthermore, the implicit assumption in Equation 6.58 may have resulted in a statistical relationship between $PT2_3$ and census division farmland values that does not necessarily have an economic basis. Since variations over time are not allowed to influence the quantities of farmland transferred, variable $PT2_3$ may be derived from a specification which imposes an inverse relationship with farmland values. For these reasons Equation 6.67 is dropped from further analysis.

The statistical features of Equations 6.62 to 6.64 are very similar since the only variable that changes in these models is the one measuring the quantity of farmland transferred. The test statistics for Equation 6.66 are superior to those of the other models, however, this equation has many of the characteristics of a reduced form model. When variables DECG2 and $DV2_{0-1}$ are specified together, they account for most of the variations in farmland values. However, these variables likely represent the total influence of a number of explanatory variables. As a result, economic relationships which illustrate the functioning of the farmland market are not fully included in this model. Equations 6.62 and 6.65 have slightly more appeal in terms of accounting for the variations over time

and over census divisions. Unfortunately, these variations are generally accounted for by dummy variables. The d–statistics for these equations suggest the presence of serial correlation among the error terms. Since the inclusion of cross–sectional observations likely reduce the dominance of time–series trends, missing explanatory variables are probably the source of the serial correlation. Equations 6.68 to 6.71 include additional explanatory variables which may have an influence on the d–statistic.

The Equations 6.68 to 6.71 estimate census division farmland values over the period from 1973 to 1976 . These equations allow of $DX23_{0-1}$ (total net income per farm taxfiler per census division), DX22/DX21 (the ratio of total off–farm net income to average gross farm income per farm taxfiler per census division), $PT2_4$ (estimated quantities of farmland transferred derived from Equation 6.59) and $PT2_5$ (estimated quantities of farmland transferred derived from Equation 6.61) to be included as explanatory variables. However, none of the estimated coefficients of these variables are statistically significant explanators of census division farmland values. Generally, the statistical results of these equations are very similar to those observed over the longer period of analysis. Variable DECG2 is statistically significant in all three models, has reasonably stable coefficient estimates and thus is consistent with the hypothesized relationship between expected real capital gains and farmland values. In the census division models the relationship between expected real capital gains and farmland values exists after variations over time and over census divisions are accounted for. The dummy variables YR73 to YR75 all have statistically significant and negative coefficients. These results confirm the observation that census division farmland values have increased over time. The dummy variables CD1 to CD14 also have similar results to those obtained for the period 1973 to 1980 . The variable X27 is included in Equation 6.71 to test whether changes in the availability of concessional credit have a direct influence on census division farmland values. X27 does not have a statistically significant coefficient, however, the inclusion of this variable reduces the coefficient estimate of DECG2. The statistical criteria for Equations 6.68 to 6.71 indicate acceptable levels of explanatory power and reliability.

The economic model used to analyze census division farmland values may limit the influence of some explanatory variables on the dependent variable. Both cross–sectional

and time-series variations are accounted for by the qualitative influence of dummy variables. Therefore, variation in the dependent variable which might be explained by an explanatory variable is already accounted for by dummy variables. Logically, the quantity of farmland transferred varies from census division to census division. However, the variation in farmland values over census divisions is largely accounted for by the dummy variables CD1 to CD14. The influence of an explanatory variable is evaluated only after time-series and cross-sectional influences are accounted for. The variable DECG2 is a sufficiently strong measure of variation over both time and census divisions to compete with the dummy variables with respect to farmland values. Availability of concessional credit, represented by X27, is also sufficiently strong to measure the variation over time and over census divisions with respect to the quantities of farmland transferred. Unfortunately, the predicted quantities of farmland transferred, concessional credit and expected productive return variables may not be able to compete with the dummy variables with respect to explaining variation in census division farmland values. As a result, the analysis of census division farmland values may be severely limited and the results are to be interpreted with caution.

D. Summary

Chapter Six presents the empirical results for economic models estimating farmland values at both the provincial and census division levels and for models which estimate the quantities of farmland transferred at the census division level. The economic models specify variables which represent forces hypothesized to have an influence on farmland values in the province of Alberta. The models are specified in linear and nonlinear functional forms and incorporate data in both real and nominal terms. The periods of observation for these models vary, primarily to include variables which were constructed from limited data.

Statistical interpretations and economic inferences are a major component of this chapter. The statistical relationships are evaluated for significance and reliability as well as for plausibility. As a result, economic rationale are incorporated into the evaluation of statistical relationships in order to infer economic relationships. As well, relationships that may be the result of statistical phenomenon are identified since they would be misleading

if used for economic inferences.

The statistical results and the performance of various models are evaluated for logical development of economic relationships which function in the farmland market. However, statistical influences, particularily multicollinearity and autocorrelation, are major obstacles to achieving a model which would represent the functioning of a farmland market in Alberta. No one particular model was superior in illustrating the functioning of the farmland market since the statistical complications associated with time-series data limit the number of explanatory variables which can be included in a model. Therefore, numerous models are employed to evaluate the variables representing hypothesized forces. As well, many of these models tend to be of a reduced form nature measuring the total influences of long term economic trends or the annual variations of short term economic cycles.

Despite the limitations imposed by statistical influences, the statistical interpretations are able to suggest relationships between economic forces and Alberta farmland values. Previous farmland values and farm enlargement appear to be the forces with the greatest relative impact on farmland values. Expectations of real capital gains and expected productive returns are also factors which might have significant influences on farmland values. Expected capital gains tend to be influenced by previous levels of gains in farmland values while expected productive returns appear to be influenced by recent levels of productive returns to farmland. The economic forces of economic development, technological progress, and concessional credit were also suggested to have influences on Alberta farmland values. The combined influence of general price increases and institutional factors which could cause private discount rates to remain low relative to increasing returns to farmland were not found to have an influence on farmland values. However there is sufficient cause to further investigate this particular influence. These relationships are derived from many different equations and are observed in models that do not necessarily reflect the interrelated nature of the many forces which have been hypothesized to have an influence on farmland values. However, these relationships can be supported by statistical relationships and economic rationale. Chapter Seven examines these statistical and economic interpretations in the light of the hypotheses of the study as well as develops economic conclusions and implications.

VII. Economic Conclusions and Implications

A. Introduction

Chapter Six presents empirical results as well as interpretations of these results from a statistical and an economic perspective. In many cases statistical relationships imply economic relationships of influences on farmland values. These economic relationships provide a basis for economic conclusions and economic implications to be developed in this chapter. Chapter Seven has three major sections. The first develops economic conclusions as to the economic relationships influencing Alberta farmland values. The second section discusses the economic implications of specific relationships influencing farmland values. In particular, the long run consequences of these relationships on farmland values are discussed. The third section summarizes the study and offers a number of suggestions for future studies of farmland values.

B. Economic Conclusions

This research focuses on the study of variations in farmland values over time. The objective is to obtain knowledge concerning the determination of farmland values. Economic relationships between specific economic factors and farmland values are hypothesized to be the functional components of farmland markets which determine Alberta farmland values. Empirical observation revealed a number of statistical relationships which suggested a number of economic relationships influencing farmland values. These statistical relationships are used to test the hypothesized relationships. The empirical testing procedure, therefore, implies economic relationships which might function with respect to Alberta farmland values.

Many of the economic variables included in the estimating equations are influenced by general economic trends and cycles. This feature is a problem with aggregated time-series data since many explanatory variables are highly correlated. As a result, the estimated coefficient of a particular explanatory variable may be influenced by the presence of a variable measuring a similar influence. Furthermore, the many interrelated economic forces which economic theory suggests influence farmland values, cannot be specified in a single model to represent the functioning of the farmland

market. The testing procedure then is based on the performance of explanatory variables over many different specifications.

Expected Productive Returns

Expected productive returns are hypothesized in Chapter Four to have a direct influence on Alberta farmland values. These expectations are described as subjective formulations of the present and future economic benefits which might accrue to farmland. These expectations were anticipated to be primarily based on economic returns and be affected by technological changes such as that involved in the substitution of capital for labor and the achievement of economies of size.

In the provincial analysis of farmland values, the performance of variables DER, $DX2_{0-1}$ and DX6 suggest an influence of expected productive returns on provincial farmland values. Economic returns to farmland are measured by the variables DER, $DX2_{0-1}$ and DX6. The estimated coefficients for these variables suggest an influence on farmland values which is consistent with the hypothesized relationship. Furthermore, variable X16 which measures farm enlargement, also appears to have a significant influence on farmland values. Farm enlargement is related to expected productive returns and in many cases it is likely to measure the influence of expected current returns as well as its own influence.

In the census division analysis, the estimated coefficients of the variables measuring economic returns to farming operations do not indicate statistically significant influences on farmland values. Cross-sectional and time-series variations in these economic returns may explain a large portion of the variation in census division farmland values. However, dummy variables account for qualitative differences over census divisions and over time in the dependent variable. Therefore, the expected productive return variables may be unable to explain variation in farmland values since these explanatory variables are evaluated only after cross-sectional and time-series variations are accounted for.

Overall, the general results of the study, particularily the time-series analysis, imply that expected productive returns are an apparent economic influence on farmland values in Alberta. Increased levels of expected productive returns tend to cause farmland values to increase. The subjective nature of expected productive returns as well as the

many components which likely contribute to assessment of this influence, may explain the varying performance of specific variables hypothesized to measure this influence and its relationship with farmland values. The elasticity relationships derived from the logarithmic transformations suggest that variable DX6 and, secondly, variable $DX2_{0-1}$ have the greatest relative influence on farmland values of all the expected productive return variables. Accordingly, the relative impact of these variables suggests that expected productive returns may tend to emphasize more recent levels of economic returns to farmland.

Inflation, Expectations and Real Capital Gains

In Chapter Four, it is noted that inflation might have differing effects on input prices and output prices and discount rates and thus might affect the behavior of farmland purchasers. The sign of the estimated coefficients of variable X10/X11 implies that greater increases in mortgage credit costs relative to agricultural product prices have an inverse influence on farmland values over the period from 1961 to 1980. Institutional factors such as concessional credit programs and fixed rate mortgages may buffer farm mortgage interest rates from general price increases. Therefore, the combined influence of an inflationary economy and these institutional factors could have a direct influence on farmland values. The estimated coefficients for variable X10/X11 do not support this anticipated relationship. However, the hypothesized relationship does deserve consideration in future studies of farmland values.

Expectations of real capital gains are also hypothesized to influence farmland values. The performance of variables DECG1 and DECG2 is consistent with this hypothesis for both the provincial and census division levels. The estimated coefficients of DECG1 in the analysis of provincial farmland values appear to be reasonably stable between the period covering 1940 to 1980 and the period covering 1961 to 1980. In the census division analyses covering the periods 1973 to 1980 and 1973 to 1976, variable DECG2 confirms the influence of the expected capital gains variable on farmland values. The results of these analyses suggest that expected real capital gains have an influence on farmland values. This implied relationship could reflect the impact of general price increases on expectations of real asset values. As well, there are many cost advantages of farmland ownership which might be reflected in this relationship. These

include preferential tax treatments on realized capital gains (for farmland) which may have considerable impact on expectations of real capital gains for farmland.

Population and Economic Development

Economic activity in Alberta, most probably originating in the energy resources sector, has been associated with increases in population growth and in real provincial incomes. As well, these features may lead to increases in the conversion of agricultural land to other uses. These forces were hypothesized to have a positive influence on agricultural land values. Variable X13 measures the gross provincial domestic product per capita in Alberta. In the provincial analysis of farmland values, X13 appears to have a statistically significant influence on farmland values which is consistent with the hypothesized relationship. Furthermore, dummy variables corresponding to Census Divisions 11 and 6 have relatively large estimated coefficients and statistical influence on census division farmland values. These particular census divisions are proximate to Edmonton and Calgary respectively and the results thus imply that high levels of population growth and income in these regions have an influence on farmland values.

Technological Progress and Farm Enlargement

Though the influences of technological progress and farm enlargement could be hypothesized to have two distinct influences on farmland values, technological advance very likely contributes to increasing farm sizes. As a result, the variable X16 which measures average farm size is taken to represent the combined influence of these hypothesized forces. The results suggest that X16 has a highly significant association with farmland values which is consistent with the hypothesis. As well, estimates of elasticity with respect to the variable X16 suggest that farm enlargement has a relatively large impact on farmland values. However, in many cases, X16 might have also been partly measuring, or at least been associated with, related forces such as expected productive returns. Therefore, estimated coefficients which relate the response in farmland values to increasing farm size must be interpreted with caution.

Selected Government Programs

The availability of and the terms associated with concessional credit are hypothesized to have an influence on farmland values. Since funds disbursed under concessional credit programs facilitate an increased demand for farmland, this hypothesis

anticipates that such programs increase farmland values. In the provincial analysis, the results for variable X17 suggest a statistical influence on farmland values which support the hypothesized relationship. In the census division analysis, variable X27 appears to have a statistically significant influence on the quantities of farmland transferred. Increased levels of concessional credit are associated with increased quantities of farmland transferred. However, neither the predetermined variable for quantities of farmland transferred or variable X27 measuring levels of concessional credit extended have a statistically significant influence on census division farmland values. However, the variation in census division farmland values may be largely explained by the dummy variables accounting for time-series and cross-sectional influences. The influence of concessional credit on farmland values (either a direct influence as an explanatory variable or a recursive influence as an explanator of quantities of farmland transferred) may not be fully revealed in the census division analysis. Accordingly, the hypothesized relationship between levels of concessional credit and variations in Alberta farmland values is not rejected.

Partial Adjustment to Economic Information

The partial adjustment hypothesis of a "sluggish" response to current economic information, developed in Chapter Four, suggests that farmland purchasers might adjust slowly to current economic forces in the farmland market and tend to rely on previous farmland values. In the provincial analysis of farmland values, the lagged dependent variable $DV1_{0-1}$ is statistically significant in all specifications, a feature which is consistent with previous farmland values having an influence on current values. This result suggests that farmland purchasers respond to previous farmland values as well as to current economic forces.

The adjustment coefficient derived from the estimated coefficient of $DV1_{0-1}$ is predicated on a weighted moving average of past farmland values. Since the adjustment coefficient is greater than 0 and less than 1, the weights appear to decline over time. The closer the adjustment coefficient is to 0, the greater is the the number of past period's prices that are included in the adjustment process. The results suggest that the time horizon (of previous farmland values) included in the adjustment process appears

relatively long.[69]

The adjustment coefficients estimated in the various equations tend to vary in response to the inclusion or exclusion of other explanatory variables. However, there does appear to be a reasonably consistent range (for the adjustment coefficient b) between .25 and .15 . This range of adjustment coefficients suggest that the adjustment process covers periods ranging from 10 to 15 years. The adjustment coefficient can also be used to calculate the long run coefficients for the parameter estimates given in the estimating equations. The long run equilibrium price for farmland cannot be observed since economic forces (which have an influence on farmland values) are continually changing. However, the adjustment coefficient is defined as a constant proportion of the difference between the long-run equilibrium price and the current price. The parameter estimates derived from the estimating equations are short-run coefficients which can be divided by the adjustment coefficient to obtain estimates of the long-run coefficients. In the provincial analysis of farmland values, when variable X16 is included in the same model as $DV1_{0-1}$ (Equations 6.19 to 6.21), this farm size variable has significantly reduced coefficients. However, dividing these estimated coefficients by the adjustment coefficients (derived from the (1-b) coefficients of the $DV1_{0-1}$ variables) gives long run coefficients of farm enlargement that are very close in value to the estimated coefficients of X16 from those model formulations when $DV1_{0-1}$ is not included. This feature could suggest that the estimated coefficients for X16 in models which do not include the lagged dependent variable (Equations 6.16 to 6.18) are long run coefficients.

The Quantity of Farmland Transferred

The hypothesis developed in Chapter Four with respect to the quantity of farmland transferred suggests that the level of transfers have an influence on farmland values. In the census division analyses, the quantities of farmland transferred are estimated in the first step of the recursive model. The predicted quantities of farmland transferred are then included as predetermined variables in estimating census division farmland values. A number of predetermined variables are tested in the equations

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[69] The number of past prices that are included in the adjustment process may be estimated by the following formula:

$$|1-(1-b)^{0+1}| \leq e$$

This formula determines the sum of weights for 0 past prices such that the amount to be included in the adjustment process is less than or equal to an arbitrarily determined small amount e . For further discussion see Nerlove (1956, pp. 496-509).

estimating farmland values; however none of these are statistically significant. Consequently, the hypothesis is not supported and is thus rejected. The limitations of the model used in analyzing pooled cross-sectional and time-series data have been discussed above. The quantity of farmland transferred is one variable which may not reveal an influence on farmland values since most of the variation in the dependent variable is accounted for by dummy variables. Therefore, the quantity of farmland transferred should be given further consideration as an influence on farmland values.

C. Economic Implications

A number of factors are indicated as having an influence on Alberta farmland values. However, this empirical analysis does not allow for definitive conclusions with respect to these factors. Alberta farmland values are determined in many individual micromarkets which are not fully linked to one another. Therefore, the relative influence of these variables may be determined by a unique set of factors in these individual markets. Specific factors such as economic returns, technology and nonagricultural influences are likely to have a continued presence in the Alberta farmland market. Long run implications for farmland values are discussed with respect to these factors.

The Productive Returns to Farmland

The productive returns to farmland are an influence on farmland values that are largely determined by commodity prices, international trade, input costs and elements of government policy. Favorable economic returns to farmland in the early and mid-1970's were largely related to increases in agricultural commodity prices. Many producers who acquired farmland prior to this time achieved real capital gains as increased agricultural incomes led to increased farmland values.

International trade, particularily with respect to grain, was and is likely to remain an important component of the productive returns to farmland. A number of events that have led to increased farmland values have originated in international markets. These appear to include undervalued North American currencies in the early 1970's, changes in world populations and income levels as well as production shortfalls. Canada's role in international grain markets may be enhanced by multilateral trade negotiations to gain greater access to world markets. However, the long run implications for farmland values

are more likely to be influenced by Canada's grain trading role which is at least partly that of a residual supplier of grain to world markets. Canadian exports of grain will likely grow in response to a moderate growth in the world demand for grain. Depending on cost levels, economic returns to farmland and farmland values might be expected to grow as well.

Recent declines in commodity prices and uncertain prospects for their improvement may cause the rate of farmland value increases to decline. Individuals who acquired farmland in anticipation of increasing economic returns may face cash flow shortages and declining levels of real capital gains. Over the 1970's reduced stocks of grain in the world market have been associated with increased volatility in future agricultural prices. Therefore, the productive returns to farmland could reflect this volatility and thus cause uncertainty in the farmland market. As well, periodic divergences between the economic returns attained in the crops sector and the livestock sector may have specific regional influences on farmland values.

Changes in input costs have tended to have a major influence on changes in the productive returns to farmland in the past 10 years. Previously, input prices were relatively stable such that variations in economic returns were primarily determined by agricultural product prices and productivity. Interest costs are a relatively recent concern in the agricultural sector. Very little is known about the influence of increasing interest costs on economic returns, however, they likely contribute to reduced productive returns. Continued high levels of interest costs, therefore, could cause farmland values to decline. Furthermore, very little is known about the adequacy of financing for agricultural producers. Consequently, whether producers are soundly financed and able to make adjustments to changing economic conditions may have an important influence on future farmland values. Established producers may be able to use their equity to make adjustments and maintain viable operations. However, some recent entrants into the agricultural sector who are highly leveraged may face severe cash flow shortages and thus might have to liquidate farm assets at a time when the market is "soft". The strength and ability of agricultural producers and other landowners to maintain ownership in land may be a major influence on farmland values.

Government programs provide benefits which increase the economic returns to farmland. The availability of concessional credit as well as the reduced interest rates these programs offer are associated with farmland values suggesting a causal relationship. Concessional credit is likely to continue to influence farmland values by way of credit availability and terms of credit. Credit availability might encourage producers to achieve economies of size which would have a positive influence on farmland values. Lower interest rates are one component of concessional credit programs that could result in increased economic returns to farmland and increased farmland values. Such specific influences between programs of concessional credit and farmland values have not been identified in this study. They are, however, certainly worthy of further investigation. Other government programs might also influence farmland values. In the Canadian context there appears to be a movement toward greater government involvement in the agriculture sector. Supply management programs limit production levels in order to generate greater economic returns to producers of specific commodities. Although these programs presently apply to land-intensive industries which do not have large land bases, the value of production quota may be capitalized into land values. Similarily, increased emphasis on income stabilization in the grain sector, might lead to benefits of the program being capitalized into land values. Existing programs which provide a degree of risk reduction could also have an influence on farmland values. Therefore, programs of crop insurance and reduced transportation costs are specific programs which could be associated with influences on farmland values.

Technology

Agricultural producers may be able to offset narrowing margins in agricultural production through the combined benefits of technological progress and economies of scale. Technology might be most apparent in the substitution of capital for labor. The adoption of mechanical technology is partially induced by increases in the price of labor relative to the price of capital and has tended to be associated with increasing farm size. Farm operators expand to achieve economies of size since the cost of production per unit is reduced. The long run implications of cost-reducing technology may well involve continued increases in farmland values. As producers strive to achieve optimum technology, they may continue to increase the optimum economic size of farms.

Technological progress in the areas of management and biology may have a more promising potential than continued machine based technology. This progress would contribute to increased economic returns to farmland and thus likely stimulate the demand for farmland. The implications of technological change are also affected by the character of demand for agricultural products. An increased supply of agricultural products together with relatively elastic or increasing demand, would result in increased economic returns and increased farmland values. In contrast, supply increases which are confronted with relatively inelastic demand where expansion of export sales is lacking would reduce industry level gross economic returns. Consequently, farmland values would be expected to decline.

Nonagricultural Influences

General price increases and the factors of economic development, population growth and rising income levels appear to be influences on farmland values that originate in the nonfarm sector. Nonfarm demand for farmland will likely be most apparent in a period of continued economic development. Periods of relatively strong economic growth are expected to lead to an expanded demand for farmland for transportation, industrial, commercial and residential purposes. In periods of moderate economic growth such urban growth is not necessarily a major user of farmland. However, the higher values of land converted to urban use can be expected to influence surrounding land. This "ripple" effect may have a relatively greater impact on farmland values than the performance of the general economy.

General price changes tend to have an influence on the economic returns to farmland. As well, general price increases could lead to expectations that previous levels of real capital gains (in farmland values) will continue. Farmland is a real asset which generates some productive returns and may have much appeal as a hedge against inflation. The future implications of this influence on farmland values may largely be dictated by monetary and fiscal policy. Policies which involve maintaining interest rates at or below the rate of inflation and, perhaps, expanded government spending may be most likely to encourage speculative demand for farmland. Policies which lead to interest rates being maintained at levels higher than the rate of inflation may well limit increases in farmland values. As a result, speculative demand for agricultural land is likely to decline as

interest costs increase and the rate of inflation declines.

D. Recommendations for Future Research

This study attempts to evaluate those economic factors which might influence farmland values in Alberta. The objectives of the study include determination of those factors which exert an influence on provincial and census division farmland values and development of models to test variables hypothesized to have an influence on farmland values. Economic theory relating to farmland values and information from previous studies were used to develop hypotheses to explain the variation in farmland values. The statistical results and economic conclusions suggest a number of factors which seem to be strong explanators of variation in farmland values. The estimated elasticity coefficients for previous farmland values and farm size suggest that these factors could have the greatest relative impact on Alberta farmland values. Expected productive returns to farmland appeared to have an influence on farmland values. Those variables which emphasized more recent levels of economic returns rather than those of many past periods appeared to have more influence. General economic development, technological progress, expectations of real capital gains and levels of concessional credit also appear to have influences on farmland values.

Not all of the objectives set out in this study are achieved. The models presented tend to be of a reduced form nature and thus do not reveal the many forces which determine farmland values. Major problems with the time-series data used in the provincial analysis are the high levels of correlation among explanatory variables. The estimated coefficients of explanatory variables are influenced by the inclusion or exclusion of other variables which might be similarily related. The aggregated nature of these data likely also contributes to the high level of correlation among the variables. Therefore, improved analyses may be gained in future studies by using data which are less highly aggregated and by using transformations of the data which might reduce the levels of correlation. The census division analysis of pooled time-series and cross-sectional data may limit economic interpretations since the method employed to evaluate the pooled data may tend to obscure the influence of explanatory variables. Other methods of evaluating pooled data, although more complex, are likely to provide a

more refined analysis. Data pooled over time and over census divisions provide a beneficial insight to farmland values and reduce the complications of multicollinearity and autocorrelation. Further research incorporating pooled data with more refined econometric techniques is highly recommended.

The analysis undertaken in this study is able to answer some questions. However, many questions remain unanswered and many new questions arise for consideration. The influence of quantities of farmland transferred was tested as a hypothesis but may have been victimized by an inefficient model. This economic force deserves greater emphasis in future studies as do the determinants of the market supply of farmland. Programs of concessional credit likely have an influence on farmland values. However, the true relationship between concessional credit and farmland values could be based on the availability of credit or the benefit of lower interest rates. Information on the relative impact of these two components of credit programs would be important knowledge in the context of better understanding the farmland market. Further questions which might be considered in the analysis of farmland values concern the importance of farm enlargement and whether expansion purchases are to achieve economies of size or to accumulate wealth. Inflation is a major factor in the determination of farmland values; however, relatively little is known about how inflation affects the behavior of market participants. Productive returns to farmland and expectations of productive returns to farmland appear to be fundamental forces in the farmland market. Unfortunately, these forces have not been sufficiently researched to determine the components of such returns, how these components have varied over time and how they are incorporated into expectations.

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Appendix A-Correlation Coefficients

Table A.1:Correlation Coefficients for Variables Presented in Table 6.2.

	ECG	CPI	$X2_{0-1}$	X6	X3	X16	V1
ECG	1.000	.8262	.8848	.9285	.8928	.6174	.9056
CPI		1.000	.9827	.9447	.9791	.9061	.9793
$X2_{0-1}$			1.000	.9673	.8646	.8507	.9862
X6				1.000	.9763	.7552	.9748
X3					1.000	.7455	.8484
X16						1.000	.8993
V1							1.000

Table A.2:Correlation Coefficients for Variables Presented in Table 6.3.

	DECG1	$DV1_{0-1}$	DER	$DX2_{0-1}$	DX6	X16	DV1
DECG1	1.000	.3976	.4988	.5973	.6497	.3269	.5727
$DV1_{0-1}$		1.000	.8947	.8562	.4834	.9492	.9726
DER			1.000	.9723	.6457	.8447	.9010
$DX2_{0-1}$				1.000	.6827	.8169	.8891
DX6					1.000	.4400	.5863
X16						1.000	.9335
DV1							1.000

Table A.3:Correlation Coefficients for Variables (logarithmic transformations) Presented in Table 6.3.

	lnDV1	lnDECG1	$\ln DV1_{0-1}$	lnDER	$\ln DX2_{0-1}$	lnDX6	lnX16
lnDV1	1.000	.4585	.9822	.8789	.8543	.4204	.9601
lnDECG1		1.000	.3341	.4483	.5333	.4632	.2873
$\ln DV1_{0-1}$			1.000	.8698	.8235	.3321	.9655
lnDER				1.000	.9667	.5370	.8257
$\ln DX2_{0-1}$					1.000	.5895	.7941
lnDX6						1.000	.3422
lnX16							1.000

Table A.4:Correlation Coefficients for Variables Presented in Table 6.4.

	DECG1	$DV1_{0-1}$	DER	$DX2_{0-1}$	DX6	X16	DV1
DECG1	1.000	.3257	.4348	.5750	.7084	.7310	.6434
$DV1_{0-1}$		1.000	.8894	.8331	.6642	.8098	.9101
DER			1.000	.9697	.7915	.8714	.8812
$DX2_{0-1}$				1.000	.8391	.8411	.8893
DX6					1.000	.7009	.8392
X16						1.000	.7796
DV1							1.000

Table A.5:Correlation Coefficients for Variables (logarithmic transformations) Presented in Table 6.4.

	lnDECG	$lnDV1_{0-1}$	lnDER	$lnDX2_{0-1}$	lnDX6	lnX16	lnDV1
lnDECG1	1.000	.1047	.2083	.3227	.4059	-.0493	.4007
$lnDV1_{0-1}$		1.000	.8897	.8246	.5665	.8216	.9208
lnDER			1.000	.9711	.7659	.8705	.9000
$lnDX2_{0-1}$				1.000	.8289	.8347	.8971
lnDX6					1.000	.6609	.7610
lnX16						1.000	.7962
DV1							1.000

Table A.6:Correlation Coefficients for Variables Presented in Table 6.5.

	DECG1	$DV1_{0-1}$	DER	DX6	X13	X17	X10/X11	DV1
DECG1	1.000	.3257	.4348	.7084	.3880	.8061	-.1460	.6434
$DV1_{0-1}$		1.000	.8894	.6642	.7863	.4999	-.9088	.9101
DER			1.000	.7915	.9255	.5509	-.8821	.8812
DX6				1.000	.8335	.8464	-.5997	.8392
X13					1.000	.6491	-.8686	.8334
X17						1.000	-.3629	.7365
X10/X11							1.000	-.8197
DV1								1.000

Table A.7:Correlation Coefficients for Variables (logarithmic transformations) Presented in Table 6.5.

	lnDECG1	$\ln DV1_{0-1}$	lnDER	$\ln DX2_{0-1}$	lnDX6	lnX16	lnX13	lnX17	lnX10/X11	lnDV1
lnDECG1	1.000	.1047	.2083	.3227	.4059	-.0493	.0842	.5059	-.0688	.4007
$\ln DV1_{0-1}$		1.000	.8897	.8246	.5665	.8216	.7950	.3789	-.8967	.9208
lnDER			1.000	.9711	.7659	.8705	.9143	.5083	-.9062	.9000
$\ln DX2_{0-1}$				1.000	.8289	.8347	.9037	.6335	-.8153	.8971
lnDX6					1.000	.6609	.7788	.8027	-.6472	.7610
lnX16						1.000	-.9778	.4428	-.9002	.7962
lnX13							1.000	.5591	-.8873	.8301
lnX17								1.000	-.3136	.6275
lnX10/X11									1.000	-.8551
lnDV1										1.000

Appendix B-Further Estimates of Provincial Farmland Values

Table B.1:Further Estimates of Provincial Farmland Values Using Nominal Value Data. (1940 to 1980).

Equation	Variable	Coefficient	Standard Error	t-statistic
B.10	X2	.1019	.0001	32.34
	(Const.)	-7.43		
Adjusted R^2: .966 F-statistic: 1046 d-statistic: .692				
B.11	X4	.0983	.001	30.82
	(Const.)	-6.50		
Adjusted R^2: .963 F-statistic: 950 d-statistic: .904				
B.12	$X4_{0-1}$	.1144	.001	34.46
	(Const.)	-12.58		
Adjusted R^2: .969 F-statistic: 1187 d-statistic: .770				
B.13	ECG	3.655	.223	16.37
	X14	1.096	.095	11.57
	(Const.)	-16.05		
Adjusted R^2: .961 F-statistic: 452 d-statistic: .796				

Table B.2:Further Estimates of Provincial Farmland Values Using Real Value Data. (1940 to 1980).

Equation	Variable	Coefficient	Standard Error	t-statistic
B.20	X16	.205	.013	15.63
	(Const.)	-54.01		
Adjusted R^2: .868 F-statistic: 244 d-statistic: .464				
B.21	X14	.8804	.071	12.43
	(Const.)	23.42		
Adjusted R^2: .8059 F-statistic: 154 d-statistic: .753				
B.22	X15	-.889	.203	-11.66
	(Const.)	258.42		
Adjusted R^2: .785 F-statistic: 136 d-statistic: .279				
B.23	$DX4_{0-1}$	.1062	.01	11.76
	(Const.)	-14.20		
Adjusted R^2: .787 F-statistic: 138 d-statistic: .952				

Table B.2(Continued):Further Estimates of Provincial Farmland Values Using Real Value Data.
(1940 to 1980)

Equation	Variable	Coefficient	Standard Error	t-statistic
B.24	$DX4_{0-1}$	.1006	.010	9.02
	DECG1	.475	.549	.864#
	(Const.)	-10.52		

Adjusted R^2: .966
F-statistic: 1046
d-statistic: .692
# indicates variable not significant at the 5 per cent level.

Equation	Variable	Coefficient	Standard Error	t-statistic
B.25	DECG1	1.487	.278	5.35
	$DX4_{0-1}$	.0158	.01	1.68#
	X16	.1629	.015	10.96
	(Const.)	-44.8		

Adjusted R^2: .951
F-statistic: 243
d-statistic: .332
# indicates variable not significant at the 5 per cent level.

Equation	Variable	Coefficient	Standard Error	t-statistic
B.26	DECG1	1.361	.331	4.38
	X15	-1.58	.169	9.31
	$DX4_{0-1}$	.0378	.01	4.18
	(Const.)	161.58		

Adjusted R^2: .938
F-statistic: 187
d-statistic: .577

Table B.2(Continued):Further Estimates of Provincial Farmland Values Using Real Value Data.
(1940 to 1980)

Equation	Variable	Coefficient	Standard Error	t-statistic
B.27	DECG1	1.39	.121	11.53
	$DV1_{0-1}$	.7387	.061	12.17
	X16	.0497	.011	4.39
	$DX4_{0-1}$	-.0009	.001	.20#
	(Const.)	145		

Adjusted R^2: .991
F-statistic: 1007
d-statistic: 1.65

Table B.3:Further Estimates of Provincial Farmland Values Using Real Value Data. (1961 to 1980).

Equation	Variable	Coefficient	Standard Error	t-statistic
B.30	X13	7.825	1.33	5.89
	DECG1	1.266	.392	3.23
	(Const.)	56.39		

Adjusted R^2: .792
F-statistic: 35
d-statistic: .284

Equation	Variable	Coefficient	Standard Error	t-statistic
B.31	DX6	-.0084	.600	0.00#
	X13	7.856	2.68	2.94
	DECG1	1.272	.618	2.05
	(Const.)	56.5		

Adjusted R^2: .778
F-statistic: 22
d-statistic: .284
# indicates variable not significant at the 5 per cent level.

Equation	Variable	Coefficient	Standard Error	t-statistic
B.32	DER	.0634	.030	2.30
	DECGI	1.087	.356	3.06
	X13	1.794	2.87	.625#
	(Const.)	27.31		

Adjusted R^2: .836
F-statistic: 32
d-statistic: .274
# indicates variable not significant at the 5 per cent level.

Table B.3(Continued):Further Estimates of Provincial Farmland Values Using Real Value Data.
(1961 to 1980)

Equation	Variable	Coefficient	Standard Error	t-statistic
B.33	$DV1_{0-1}$	.7995	.125	6.38
	X17	.347	.096	4.06
	X13	.840	1.38	.611#
	(Const.)	3.70		

Adjusted R^2: .923
F-statistic: 73
d-statistic: 1.95

Equation	Variable	Coefficient	Standard Error	t-statistic
B.34	X13	8.10	1.74	4.66
	DECG1	1.401	.659	2.13
	X17	-.0613	.240	.261#
	(Const.)	57.21		

Adjusted R^2: .779
F-statistic: 22
d-statistic: .280
# indicates variable not significant at the 5 per cent level.

Equation	Variable	Coefficient	Standard Error	t-statistic
B.35	$DV1_{0-1}$	.695	.165	4.22
	X17	.349	.080	4.62
	DER	.075	.020	1.12#
	(Const.)	5.60		

Adjusted R^2: .931
F-statistic: 82
d-statistic: 1.25
# indicates variable not significant at the 5 per cent level.

Table B.3(Continued):Further Estimates of Provincial Farmland Values Using Real Value Data.
(1961 to 1980)

Equation	Variable	Coefficient	Standard Error	t-statistic
B.36	$DV1_{0-1}$	.7764	.099	7.83
	X17	.235	.120	2.00
	DX6	.396	.270	1.48#
	(Const.)	-.533		

Adjusted R^2: .931
F-statistic: 82
d-statistic: .1.25
# indicates variable not significant at the 5 per cent level.

Equation	Variable	Coefficient	Standard Error	t-statistic
B.36	X10/X11	-.3898	.029	13.44
	DECG1	1.798	.185	9.69
	(Const.)	146.13		

Adjusted R^2: .946
F-statistic: 160
d-statistic: .942